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AN EVALUATION OF THE PRODUCTION CONTROL PROCEDURE AT THE NAVAL ORDNANCE PLANT INDIANAPOLIS

A Thesis

Submitted to the Faculty

of

Purdue University

by

Gordon E. Hartley

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science in Industrial Engineering

June, 1950

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H296

ACKNOWLEDGEMENT

The majority of the principles expounded herein have been the natural result of numerous conferences with people engaged in Production Control today integrated with the concepts of production control as taught in current academic courses. It is indeed proper that this acknowledgement be made to give credit, where appropriate, for the data obtained.

To Captain A. D. Blackledge, Commanding Officer, Naval Ordnance Plant, Indianapolis; to Mr. D. D. Dennis, Head of the Production Control Division; and to the staff of the plant, whose sincere and extremely helpful cooperation greatly aided the investigation, the author wishes to express his deepest gratitude.

Profound appreciation is extended to Professor Halsey F. Owen of the Industrial Engineering Department, Purdue University, for his excellent guidance throughout the study.

13250

TABLE OF CONTENTS

Table of Contents

LIST OF FIGURES

Table of Contents

ABSTRACT

This study was undertaken in order that an evaluation could be made of the production control procedure employed by the Naval Ordnance Plant, Indianapolis, Indiana. The criteria upon which the evaluation was based included various basic principles of production control that are expounded by several authors of current production control literature, and which are taught in current academic courses.

The majority of the material upon which the investigation is based was obtained at the Naval Ordnance Plant, Indianapolis, Indiana. Conferences were used as a means of gathering the information necessary from each responsible individual of the Production Control Division. These conferences as well as the observation of the day to day accomplishment of the production control functions resulted in a thorough coverage of the units and their responsibilities in the production control procedure as it is practiced at the plant. The information gathered and the procedures observed were then compared with the criteria of generally accepted production control procedures.

The results of this evaluation are most gratifying. In terms of the criteria used, the Naval Ordnance Plant, Indianapolis, Indiana, has a progressive production control procedure that has been planned and executed by very capable and farsighted individuals who have recognized the potentialities of a flexible procedure of production control. Considering the needs of the plant, it can be concluded that no major modifications to the present system are needed and that only a very few minor techniques could be improved.

AN EVALUATION OF THE PRODUCTION CONTROL PROCEDURE AT THE NAVAL ORDNANCE PLANT INDIANAPOLIS

INTRODUCTION

The field of production control has felt the impact of the demands placed on it by a Second World War and the changes wrought by the postwar era of shortages of material, disparity of price rises, difficulty of sales forecast, and other extreme uncertainties. No system or procedure could remain static under the ever-changing demands of the industrial world as portrayed by the examples above. Upheavals in the social, economical, and political aspect of our American way of life also have had their part in molding changes in the concept of production control. This study was undertaken to evaluate the application of the basic principles of production control at the Naval Ordnance Plant, Indianapolis, Indiana, hereinafter referred to as NOPI, and what deviations from or modifications of these basic principles have resulted from the conditions evolving because of the particularly specialized work accomplished by NOPI.

Work done previously which is related to this problem includes a thesis by Lieutenant Colonel Robert W. Brooks, USA, "An Appraisal of the Production Control Methods Used in Government Arsenals," June 1947. This thesis dealt with the production control methods applicable to the problems of chemical manufacture.

The majority of the information upon which this study is based was obtained at NOPI. Conferences with unit personnel in the Production Control Division were used to accumulate sufficient information about the functions of the individual unit to describe in general its respon-

sibilities and place in the organizational structure of the division. Using this information as a basis for investigation, this study was compiled by considering the functions of production control as practiced at MCPI in comparison to the criteria of generally accepted production control procedures.

The interpretations of the definition of production control as expressed by many authors in current literature have an extremely broad scope. For the purpose of this study, production control will be defined as the mental and physical know-how applied in such a manner that the right quantity and quality of a product will be produced at the right time by the best and cheapest methods. Although there is a wide diversity of opinion in the literature on production control as to the functions which should be included in a production control procedure, the functions listed below are a few of those appearing in the texts of the Bibliography, and they will be considered as a criteria for this study.

1. The preparation and issuing of production orders and forms
2. Purchase requisitioning of raw materials and special items
3. Preparation of route sheets
4. Work scheduling
5. Plant loading
6. Work dispatching
7. Determination of the labor requirements
8. Maintenance of production records
9. Expediting of manufactured and purchased items
10. Analysis of idle machine time

10. Complete all this exercise item

9. Remember to underline your solutions first

8. Underline the [illegible] in [illegible] sentence

7. Underline all the [illegible] sentences

6. Some [illegible]

5. [illegible] Another

4. Some sentences

3. Underline all these words

2. Sometimes underlining at the wrong time [illegible]

1. The [illegible] are important in [illegible] should not alone

words.

the [illegible] may [illegible] be considered to a solution [illegible] the [illegible] Linked Below was a [illegible] of [illegible] in this [illegible] of [illegible] [illegible] [illegible]

THE NAVAL ORDNANCE PLANT, INDIANAPOLIS, INDIANA

The History, Organization, and Physical Properties of the
U. S. Naval Ordnance Plant, Indianapolis, Indiana

This plant was designed, constructed, and staffed by a civilian engineering company during World War II for the purpose of manufacturing the Norden bombsight and related equipment, and aircraft lead-computing gunsight systems; some sixty thousand fire control instruments were manufactured during World War II.

Late in 1945, the plant was taken over by the Navy. It is now being run under the cognizance of the Bureau of Ordnance, Navy Department. As a Naval Shore Establishment, the plant has the following functions:

(1) research in, and engineering development of, aviation fire control equipment;

(2) the manufacture of that equipment;

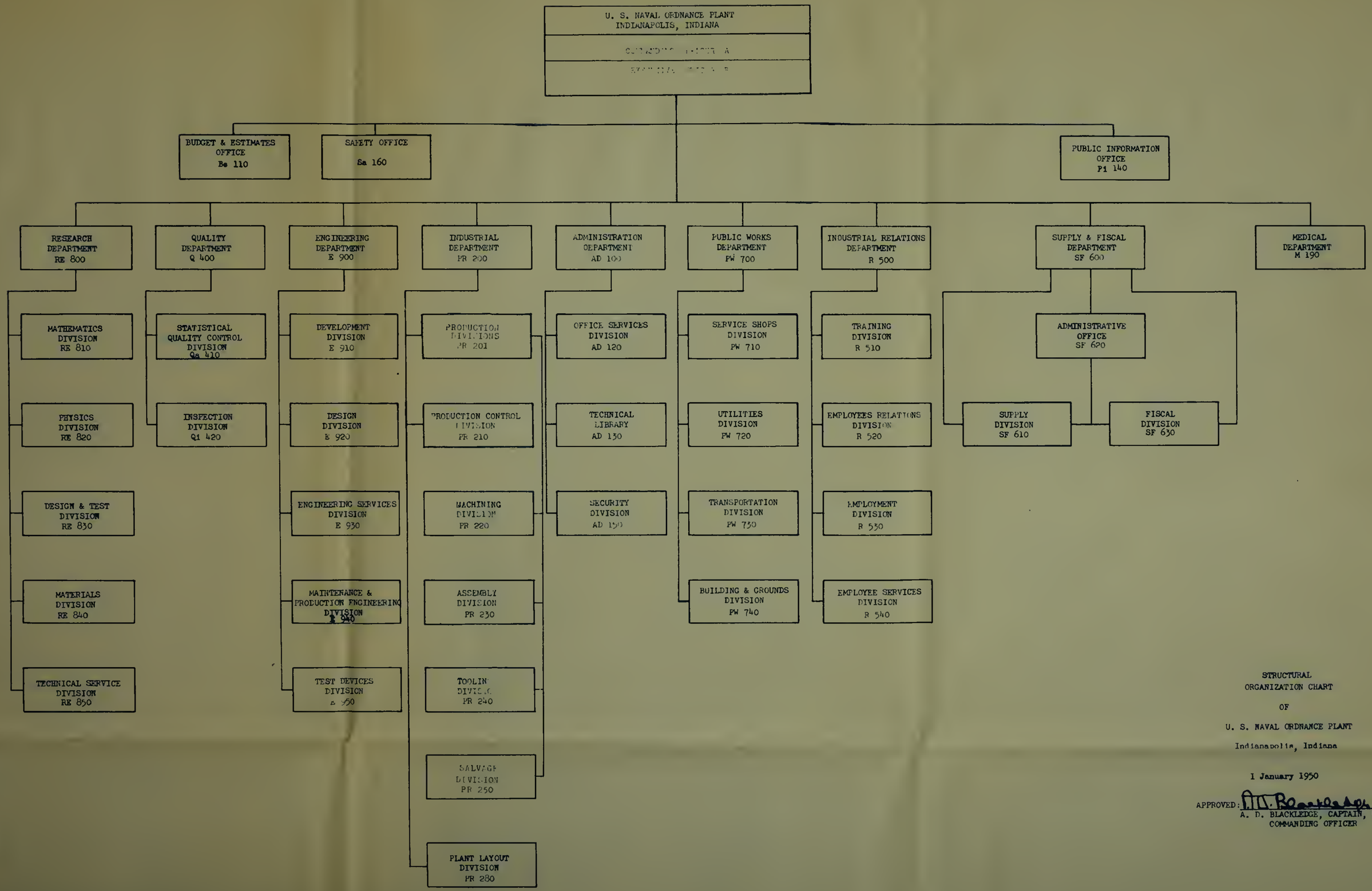
(3) the manufacture of line maintenance stores;

(4) the overhaul, modification, and modernization of fire control instruments, including radar attachments and their accessories.

The present staff of the plant consists of the original employees who were inducted into the Civil Service system at the time of conversion to naval control. Assigned to the plant are 11 naval officers and 5 enlisted men, and 1 Marine officer and 40 enlisted men. These officers and men serve in the following capacities at the plant: As Commanding Officer and Executive Officer, and in the Budget Office, the Security Division, the Safety Office, the Communications Office, the Supply and Fiscal Department, and the Medical Department.

Organized under the direction of the Commanding Officer with the assistance of the Executive Officer, the plant has nine departments. These departments are divided into divisions composed of sections, which are in turn subdivided into units. A structural organization chart of the plant at the divisional level appears in Figure 1.

Located in northeastern Indianapolis, Indiana, the plant occupies some one-hundred-sixty acres of land. Its main structure, the manufacturing building, is nine-hundred-twenty feet long and five-hundred-sixty feet wide, covering eleven and a half acres of floor space. The plant facilities are of the most modern type, including an air-conditioning system affording constant temperature and controlled humidity, with six complete changes of inside air cleared through an electrostatic filter in one hour. Heat is supplied by two oil-burning steam boilers. The lighting system employs both direct and indirect facilities, and maintains a one-hundred foot candle intensity at the work stations. These modern facilities afford to the plant's staff the maximum in comfort and ideal working conditions.



STRUCTURAL
ORGANIZATION CHART

OF

U. S. NAVAL ORDNANCE PLANT

Indianapolis, Indiana

1 January 1950

APPROVED: A. D. Blackledge

A. D. BLACKLEDGE, CAPTAIN, USN
COMMANDING OFFICER

The Nature of the Product

The product of the plant is aviation fire control systems, engineered and manufactured to meet service performance requirements and specifications. The mathematical expressions for the solution of various fire control situations are mechanized to a fine degree of accuracy. Mechanical and electronic methods translate the theoretical principles into useable systems.

A component unit of a fire control system is, in reality, a precision instrument. The exactness in the manufacture of a unit's individual parts is comparable to that employed by the most skilled toolmakers in industry.

There is a great variety of products among the aviation fire control systems. Thus, the system which is installed in a fighter to control the fire of its guns is vastly different from that installed in a high-altitude bomber to control the dropping of its bombs. The addition of controls for torpedoes, rockets, and air-launched guided missiles further increases the dissimilarity between the fire control systems.

The product of the plant is, therefore, precision instruments possessing little uniformity among themselves.

The Problem of Production Control

The plant is engaged in a combination of the job shop and intermittent types of manufacture. This type of manufacture is characterized by the production of special orders and of a great variety of products in limited quantities. In a year's time, the plant may receive three-hundred special orders which will require the production of one-hundred-thousand different items in average quantities of twenty-five units per item.

Some of the factors which necessitate a complex production control system are:

1. Number of ultimate parts in the product.
2. Number of different operations on each part.
3. Extent to which processes are dependent, i.e., those which cannot be performed until previous operations have been completed.
4. Variation in capacity of machines for different classes of work. In many industries speed of machines varies according to the nature of the material being worked on.
5. Degree to which subassembly exists.
6. Degree to which customers' orders with specific delivery dates occur.
7. Receipt of orders for many small lots.[1]

The fact that the product, aviation fire control equipment, is comprised of precision instruments having large variety among themselves accentuates the factors listed above.

The machine tools in the plant are of the general purpose type. On the whole, there is a surplus of machine tools. The special nature and complexity of the finished product necessitates the designing of special testing equipment. Normally, available commercial test equipment is modified to meet the plant's special needs. In some cases,

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[1] Alford, L. P., Bangs, John R., Production Handbook, The Ronald Press Company, New York, N. Y., 1944, pp. 75.

[illegible]

[illegible] E. F., Smith, John H., Contemporary Psychology, The Ronald Press Company, New York, N. Y., 1944, pp. 75.

however, test equipment must be designed from basic fundamentals.

The employees in the Machining and Assembly Divisions are skilled craftsmen. Each machinist is capable of operating several types of machine tools. The Assembly Division employees are, in many cases, qualified machine operators; and the machinists, in turn, are capable of doing assembly work. Thus, when the plant is overloaded with machine tool work, the Assembly Division employees can be transferred to the Machining Division. The control of such inter-division personnel is a function of the Production Control Division.

To summarize, the nature of the product, the special equipment required in its manufacture, and the skilled staff of the plant present complex problems which must be solved by the Production Control Division.

The Production Control Division

The Organization of the Production Control Division.

The Production Control Division, one of six divisions comprising the Industrial Department, consists of three sections, the Planning, Methods, and Progress Sections. Each of these is divided into various units. The organization chart of the Industrial Department, including the unit breakdown, appears in Figure 2.

The Responsibilities of the Production Control Division.

The Production Control Division plans and directs the scheduling of production activities; provides materials, tools, and specific manufacturing instructions for the operating shops; maintains daily floor checks to eliminate delays and work stoppages; moves stores and disposes of all manufactured items; is the source of all data on production performance, current and anticipated plant productive load, estimated productive and non-productive expenditures, current budget status of productive projects and the Industrial Department's maintenance allocations; acts in an advisory capacity in the matter of employment level and confers with the Engineering Department in the matter of product design for economical manufacture.

The responsibilities of the sections of the Production Control Division are as follows:

The Planning Section is charged with the responsibility of both long range and specific project planning and scheduling; the ordering of raw materials and purchased parts; the issuance of shop order kits; the preparation of charts and graphs indicating production performance trends, and other statistical production data; the compilation and reporting of production costs to provide comparison between the

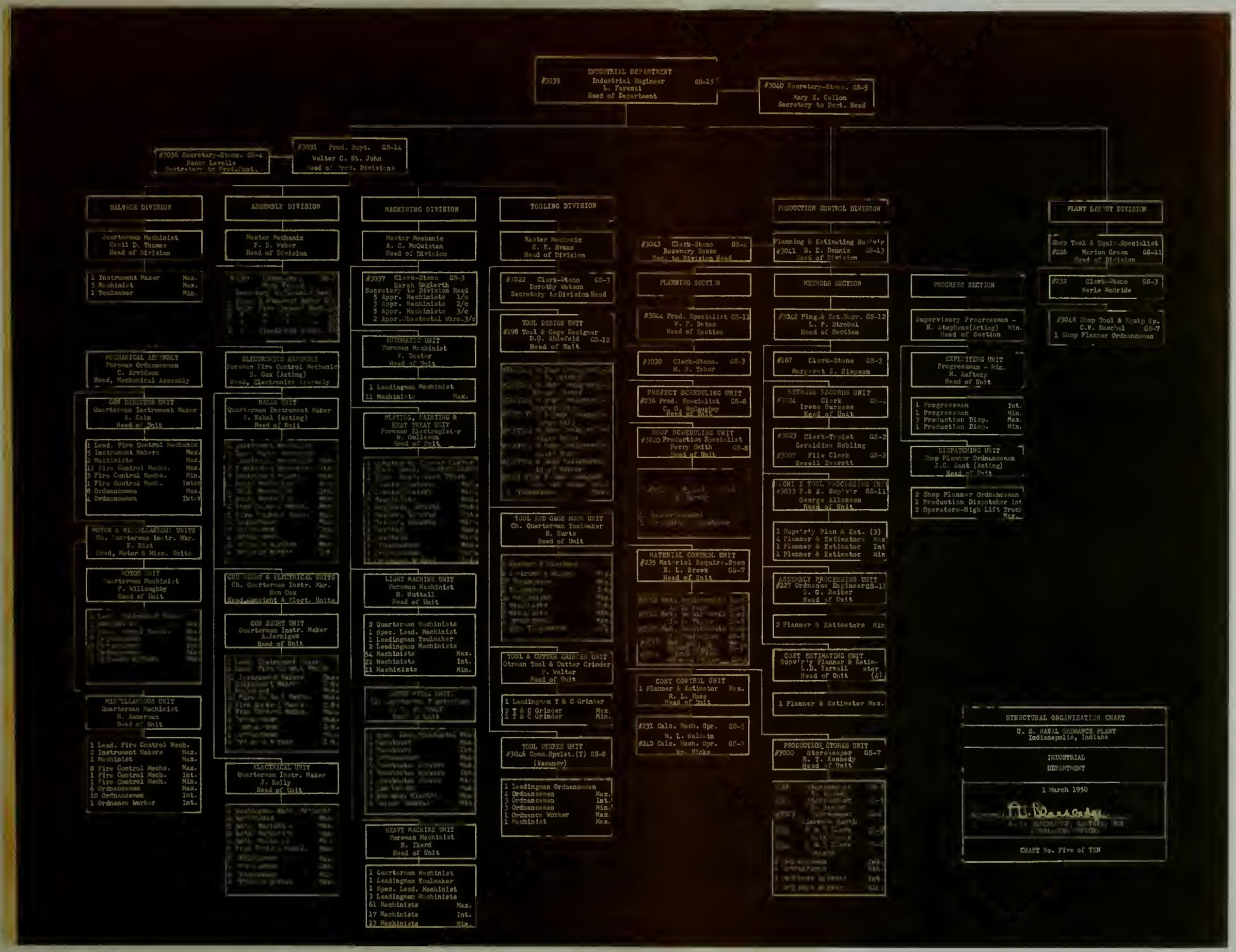

Fig. 2 Organization Chart of Industrial Department

original estimate and the actual expenditure; and the control of project expenditures.

The Methods Section is responsible for cost estimation for the proposed production work; the preparation of detailed process routing sheets (operation sheets) for component parts, sub-assemblies, finished units, and the necessary time to perform such operations; the ordering of all special tools and gages; the designing and ordering of special test equipment; conferring with the Engineering Department regarding changes of design which will facilitate production and lower costs; the receipt, recording, and distribution of engineering information to the Industrial Department; the advising of the Plant Layout Division regarding the placement of machine tool equipment; and the recommendation of procurement of specialized machine tool equipment and accessories.

The Progress Section is charged with the responsibility of distributing the shop order kits; insuring the completion of scheduled work on time; expediting the procurement of raw materials, tools, gages, and purchased parts; conferring with the various departments regarding solutions of production "bottlenecks;" reporting weekly the production status of projects; and the inter-divisional handling of materials.

The Handling of a Proposal

The Bureau of Ordnance, before allocating funds or authorizing a plant to begin work on a project, requires each plant interested in bidding on the work to submit an estimate or proposal as to the expected delivery date of the first completed item and the approximate cost of the project. Generally in letter form, the Bureau's request for this estimate is accompanied by rough prints and parts lists pertaining to the product, or by a word description of the product.

This letter is received and processed by the Budget Office of the plant administration. The Proposal or Cost Estimation and Scheduling Form (Blue), Figure 3, is originated in that office and accompanies the prints to the Engineering Department, where they are examined for the purpose of estimating an engineering release date. This date is then entered on the proposal.

From the Engineering Department the proposal and attachments then go to the Cost Estimating Unit of the Production Control Department, where all the remaining estimates, with the exception of the delivery schedule, are made. The Cost Estimating Unit fills in the cost estimate columns of the proposal in terms of dollars only. The method used to arrive at these estimates will be described later in a section on this unit.

When the above cost estimation is complete, the proposal is then returned to the Project Scheduling Unit, where an estimate is made as to where in the work load the project can be placed, when delivery on the finished products can be expected, and in what quantity they can be completed during each period until the project's termination.

The proposal and its accompanying papers are then returned to

The Handling of a Proposal

The Reviews of Proposals, before allocating funds to maintain-
ing a place in Depth work on a Problem, requires much input information
in writing on the work to be undertaken or proposed on to the ex-
pected outcomes/ends of the first completed item and the objectives
some of the Problem. Generally in larger form, the Summary should for
able methods is accompanied by enough brief main items information
on the project, or in a real description of the problem.

This letter is accepted and processed by the Major Office of
the Plant Activities. The Proposal or Data Initially as Commun-
ication (Form) Figure 3, is originated in this office and acknowledge
the points in the Explanation Sheet, which are accepted for
the Purpose of Validation Purposes. This data is
then entered on the Sheet.

Then the Application Department are prepared any attachments
also by an Data Initially at the Processing Control Department,
where all the Completed entrance, with the completion of the Initial
Control, are made. The Does Control Not Fill in the main entrance
of the Proposal in terms of Dollars only. The entries made in
earlier of these methods will be described later in a section on this
topic.

When the above main validation is complete, the Proposal is
then entered on the Project Inventory Unit, where it accumulate in case
it is ahead in the work load the project may be given. When Initial
or the Started Procedure due be accepted, all in that Quantity they are
completed during each period until the Project's Completion.

U. S. NAVAL ORDNANCE PLANT — INDIANAPOLIS

COST ESTIMATION AND SCHEDULING FORM

PROPOSITION _____ PROPOSITION _____

BuOrd Authority:
PROJECT ORDER NO. _____ EXPIRES _____ ORIGINATING DATE _____
CLASS OF ESTIMATE _____ JOB ORDER NO. _____
TASK: _____ REVISION DATE _____
Classification:

ITEM	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	COST ESTIMATE LABOR	MAT'L	MISC.	TOTAL
ENGINEERING RELEASE																																		
PACKAGING RELEASE																																		
MOULDINGS & CASTINGS																																		
PROCESSING																																		
RAW MATERIAL																																		
PURCHASED ITEMS																																		
TOOLING																																		
MACHINING SECTION (HOURS)																																		
ASSEMBLY SECTION (HOURS)																																		
PACKAGING (HOURS)																																		
TOTALS (HOURS)																																		
DELIVERY SCHEDULE (PER MO.)																															Appropriation: - -			
																															Expenditure Account: - -			

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Fig. 3 Cost Estimation and Scheduling Form

the Budget Office for final review, issuance, and submission to the applicable activity.

These estimations and information are presented in general form and are regarded as a tentative commitment by the plant. They serve as a broad basis for planning by the Bureau of Ordnance, for cost estimation and approximate delivery schedules.

The Handling of a Firm Estimate

When the Bureau of Ordnance has decided to authorize the plant to begin work on a project and has allocated the necessary funds, this authority and allocation come to the plant in the form of a project order number and an allotment number. These are received by the Budget Office and are processed in the same manner as was the information pertaining to a proposal.

The Firm Estimate or the Cost Estimation and Scheduling Form (White), Figure 4, is originated by the Budget Office and differs from the proposal only in color and the amount of information thereon. This form and current pertinent information, which may include more detailed prints and/or parts lists, are forwarded to the Engineering Department. The Engineering Department proceeds as expeditiously as possible with the work of originating production engineering releases without awaiting a formal job order. This precludes delay of the engineering release because of delay in issuing a job order. If the firm estimates are accompanied by a work description only, the Engineering Department develops the prints and parts lists. A revised engineering release date is made in greater detail than in the case of the proposal.

The originated or revised prints and parts lists are sent to the Methods Records Unit, who transmits a copy to the Material Control Unit. The Material Control Unit uses the information from the parts lists to determine whether the parts can be obtained from the Supply system or whether they will have to be procured in another manner.

This information, together with the firm estimate, is then passed to the Cost Estimating Unit. Using the information furnished by Budget, Engineering, and Supply, and their own internal work forms, the

13256

1342

COST ESTIMATION AND SCHEDULING FORM

BU.ORD. AUTHORITY _____ EXPIRES _____ ORIGINATING DATE _____

CLASS OF ESTIMATE _____ PROJECT JOB ORDER NO. _____

TASK: _____ REVISION DATE _____

ITEM	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	COST ESTIMATE LABOR	MAT'L.	MISC.	TOTA
ENGINEERING RELEASE																												
PACKAGING RELEASE																												
MOULDINGS & CASTINGS																												
PROCESSING																												
RAW MATERIAL																												
PURCHASED ITEMS																												
TOOLING																												
MACHINING SECTION (HOURS)																												
ASSEMBLY SECTION (HOURS)																												
PACKAGING (HOURS)																												
TOTALS (HOURS)																												
DELIVERY SCHEDULE (PER MO.)																												

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Fig. 4 Cost Estimation and Scheduling Form

Cost Estimating Unit makes an accurate estimate of the costs that will be incurred in the process of manufacturing a complete project. This estimate is made as a result of more meticulous investigation then was afforded the proposal.

The Firm Estimate is then returned to the Project Scheduling Unit for processing similar, with a few exception, to that given the proposal. As well as estimating the delivery schedule, this unit breaks down each cost figure into man-hours and loads the firm order by months. Consideration is given to the total available man-hour capacity of the plant and to the already existing load when the loading of a new project is undertaken.

The completed Firm Estimate is then returned to the Budget Office for final review, issuance, and submission to the applicable activity.

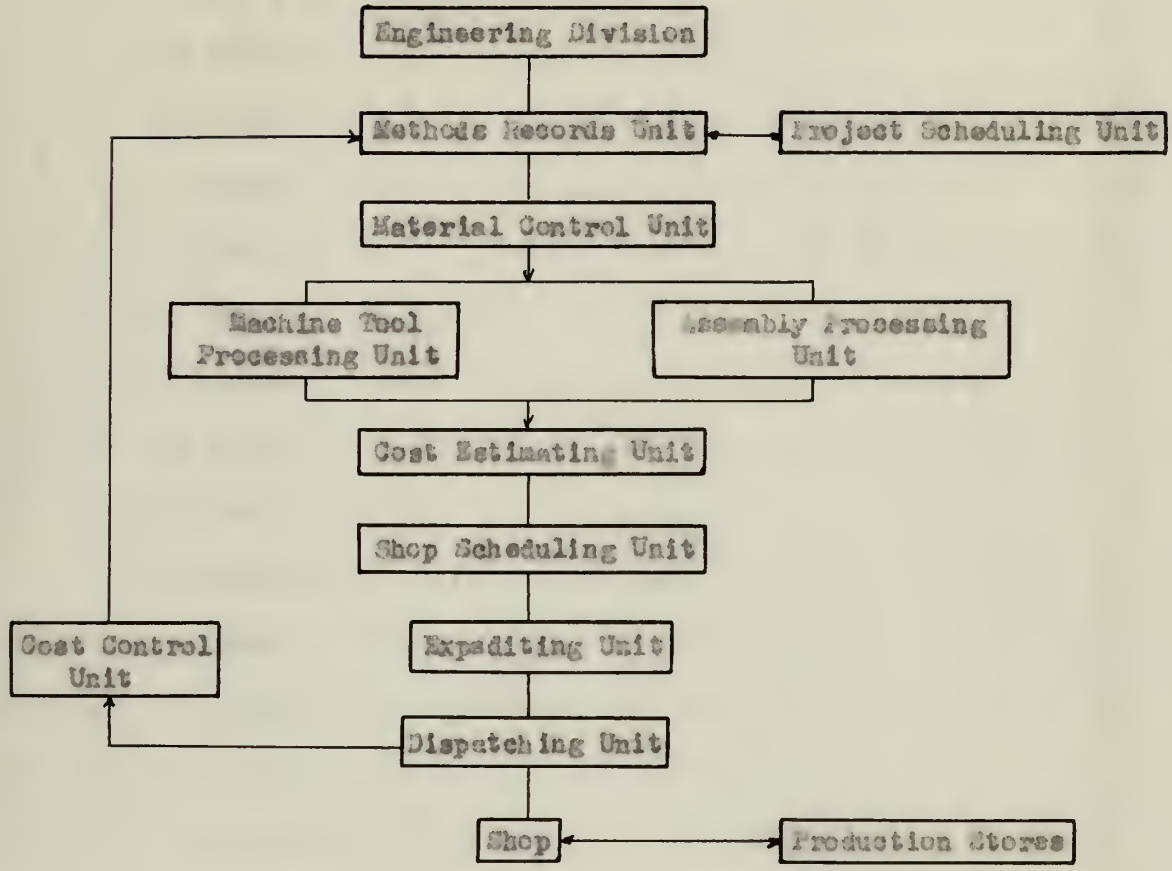
As was noted in this discussion, the estimates and information presented are the result of extended investigation and are considered a definite commitment by the plant, since they are specific information pertaining to the Bureau's planning regarding costs and scheduled delivery dates.

The firm Cost Estimation and Scheduling Form for a project actuates the flow of work in the Production Control Division. There is a great exchange of information between Units which, if included in a general flow diagram, would become confusing, defeating the diagram's general purpose of giving an over-all picture of the work flow in the Production Control Division. Only the general pattern of the work flow is indicated and only the more important forms mentioned in the description of the functions of the various Units. The following diagram shows the general flow of work between the Units of the Production Control Division.

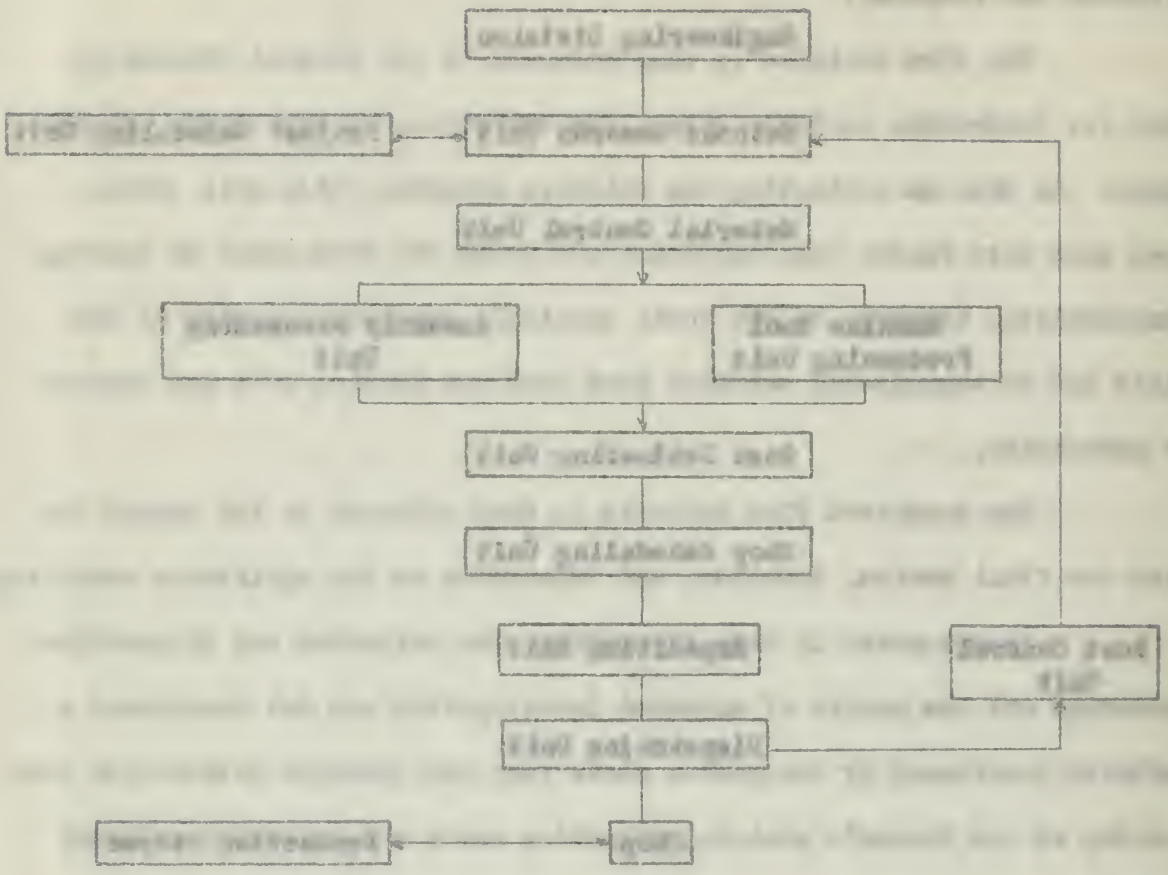
the general flow of work between the units of the Production Control
Division.

General Work Flow Diagram

Production Control Division



The functions of the various Units are described in the following pages.



The Project Scheduling Unit

The Project Scheduling Unit plans the over-all plant schedule, issues the internal scheduling for the Production Divisions, and compiles certain important production statistics which aid in formulating the plant's labor requirements.

The following forms are originated in the Project Scheduling Unit: The Internal Schedule Form, shown in Figure 5, indicates the required completion dates of a project. The information contained in this form is taken from the Cost Estimation and Scheduling Form, and is distributed throughout the plant. Each division advises the Unit as it completes its portion of the project, thus furnishing the Unit with an accurate record of the status of each project.

The Forecast of Productive Labor, Figure 6, is a chart which displays the over-all plant production forecast in terms of man-hours, projected eighteen months ahead. The data is divided into program numbers, and represents the load on the various departments. The main function of this chart is to determine the amount of new work which can be undertaken by the plant in the near future. The chart is sent to the Bureau of Ordnance via the plant administration.

The Load and Performance Chart, shown in Figure 7, represents the efficiency of the shop relative to the time estimates of the Cost Estimating Unit. This chart serves as an efficiency standard for the shop, showing the amount of work completed by the shop against the amount of work released to the shop by the Production Control Division. Sources of the chart's information are the Weekly Machine Load Report and the Fiscal Labor Report.

The Monthly Man Load Summary is in the form of a letter stating

The Project Proposal Unit

J. O. #

Complete Engineering Release

Operation	Due	Complete
Final BD & BM's		
Make Routings		
Make Kits		
Assy Routings		
Assy Kits		
Raw Materials		
Purchased Parts		
Make Parts		

Remarks:

(1) If for any reason your portion of the above schedule cannot be met, please notify the undersigned immediately.

(2) When your portion of the above schedule is completed, please date, initial and return this form to the undersigned.

C. O. McGaughey
Project Scheduling Unit

Fig. 5 Internal Schedule

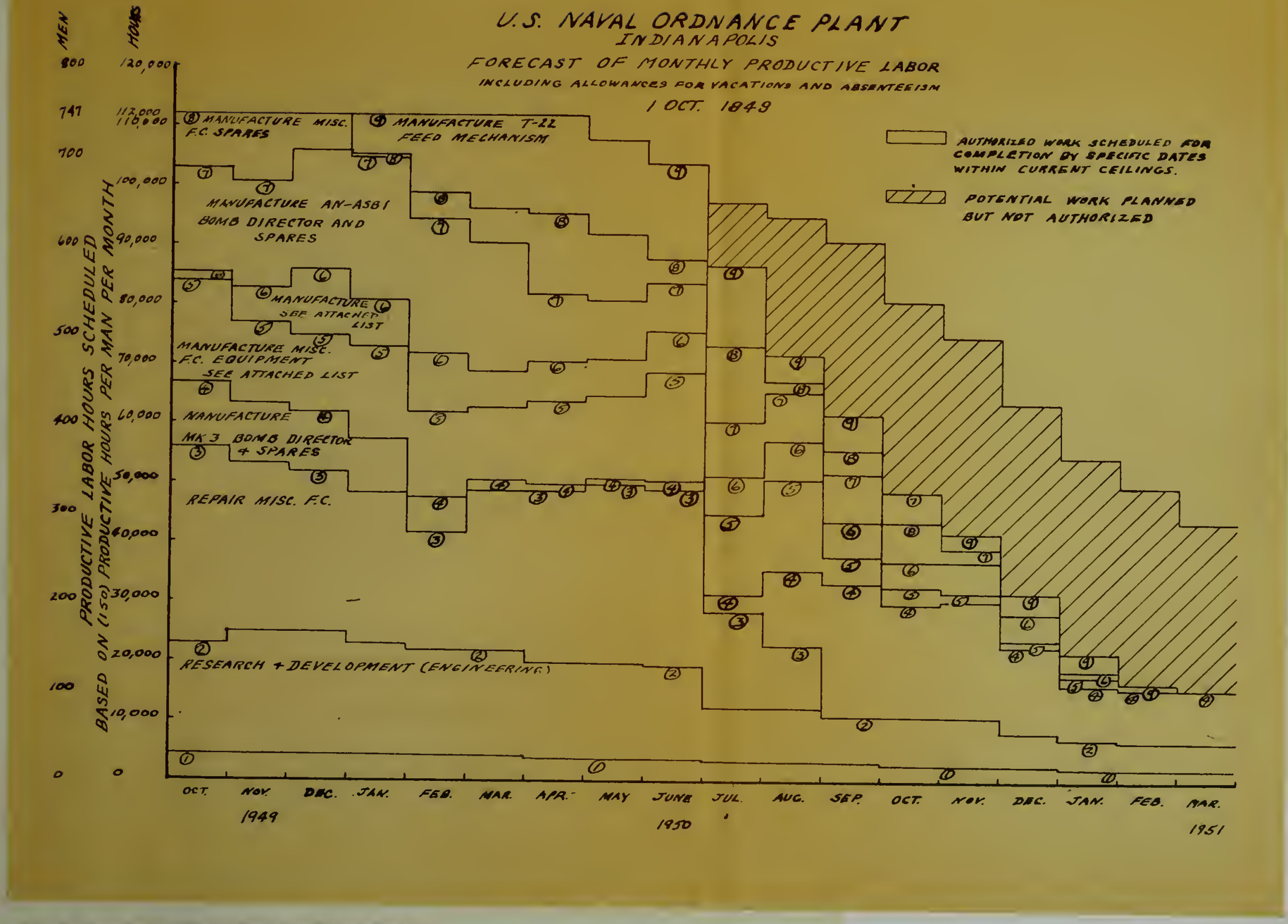


Fig. 6 Forecast of Productive Labor Chart

D-200 MAN LOAD & PERFORMANCE CHART

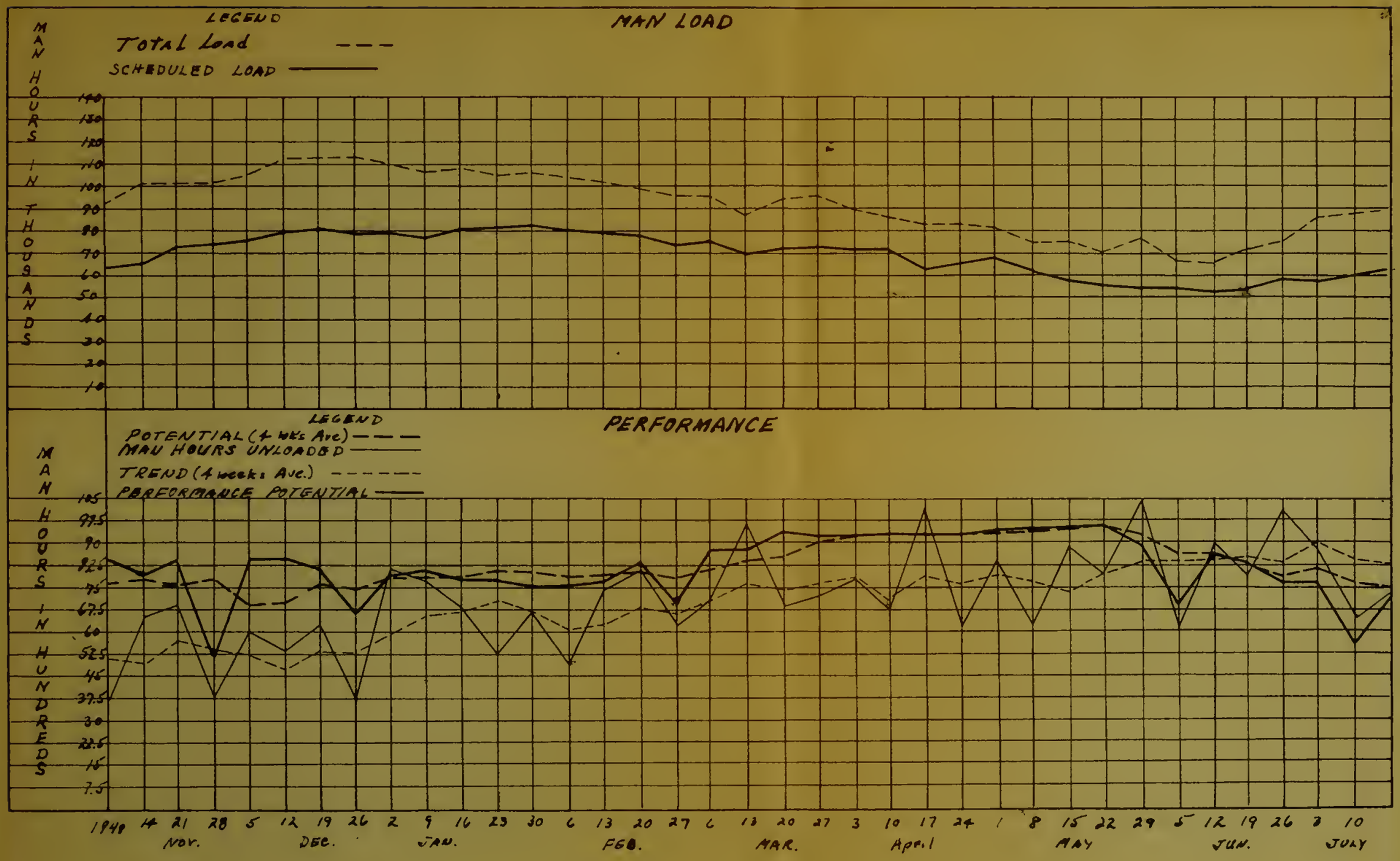
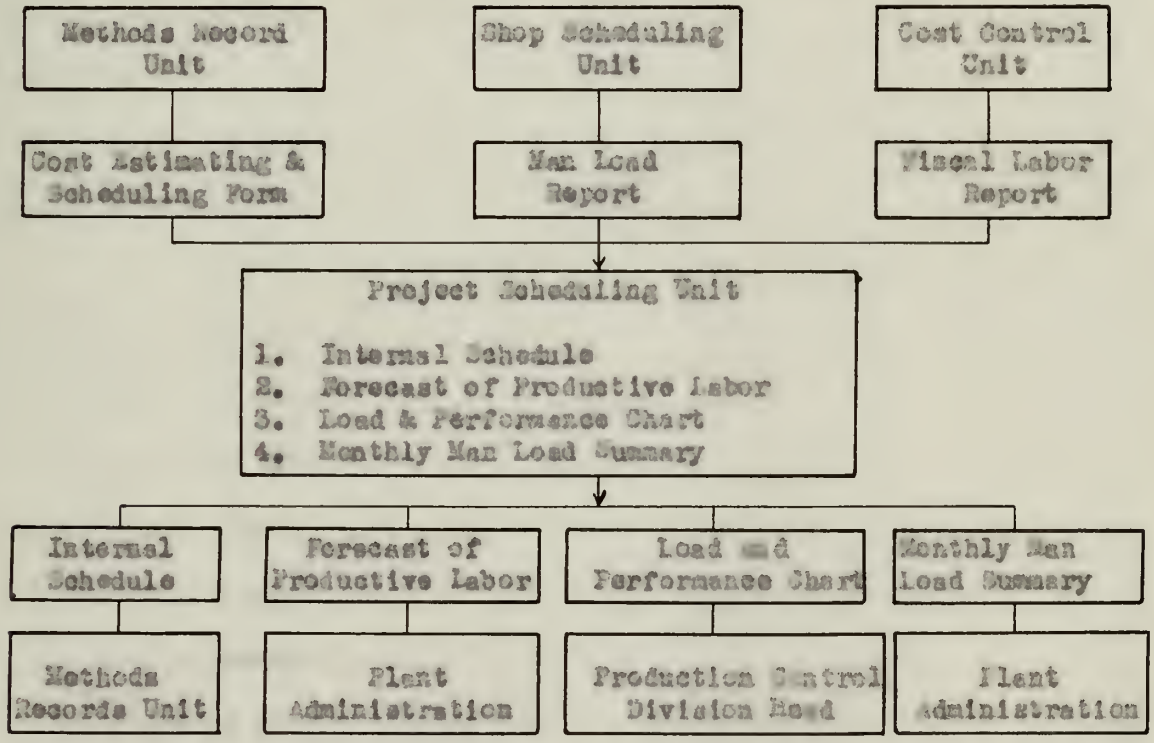


Fig. 7 Load and Performance Chart

the man-hours of machinery, assembly, and tooling completed in a month. Based on the Forecast of Productive Labor, this summary recommends transfers of labor between divisions and the adjustment of the labor force to meet the production requirements of the immediate future. It also contains a brief account of the status of all projects, a report on the important occurrences in and outside of the plant during the past month (such as a national coal strike), and their effect on the progress of the plant's various projects. This summary is used for administrative guidance.

The flow of information into the Unit, the forms originated therein, and their destination are shown in the diagram below.



The Methods Records Unit

The Methods Records Unit is responsible for receipt, stowage and distribution of Engineering data and for keeping the many files up to date. These files contain a variety of items, such as job orders, blueprints, parts lists, production breakdown sheets, and many others. One of the other responsibilities of the Unit is to act as a collecting agency in making up the "folders" that are originated to implement the production of a new part. It is obvious that it is necessary to have some means of keeping track of just how each job is progressing pertaining to the necessary preparation of prints, routings, and such other work that must be completed prior to release of the job order to the Shop Scheduling Unit. The Methods Records Unit accomplishes these functions.

When a new part appears on the Production Breakdown Sheet, a folder containing the necessary information on the part is made up and sent to the Machine Tool Processing Unit where the Process Routing Sheet is made up on vellum paper. This accompanies the folder and is then sent to the Cost Estimating Unit via the Methods Records Unit so that they are able to tell at all times just what progress is being made on the "folder." The Cost Estimating Unit fills in the operator and set-up times in the proper columns on the Process Routing Sheet, and the folder is then returned to the Methods Records Unit for reproduction and distribution of the Process Routing Sheet. The folder is kept in a current file as long as the part is being produced in the plant.

Items of different form are received by the Unit, reproduced in the required number and distributed according to the needs. For instance, Parts Lists are reproduced and sent to the following:

1. Original to file
2. Material Control
3. Assembly
4. Methods Processing

Blueprints are reproduced and sent to the following:

1. Original to file
2. Tool Design
3. Salvage
4. Machine Shop
5. Assembly

Process Routing Sheets are reproduced and sent to the following:

1. Original vellum into file
2. Machine Shop
3. Assembly
4. Inspection
5. Tool Design
6. Tool Room
7. Scheduling
8. Salvage

1. Religious Values
2. Economic Values
3. Aesthetic Values
4. Social Values
5. Political Values
6. Health Values
7. Knowledge
8. Safety

Examples are provided and must be followed.

1. Religious Values
2. Economic Values
3. Aesthetic Values
4. Social Values
5. Political Values
6. Health Values
7. Knowledge
8. Safety

Please indicate your response and mark it in the following:

1. Religious Values
2. Economic Values
3. Aesthetic Values
4. Social Values
5. Political Values
6. Health Values
7. Knowledge
8. Safety

The Material Control Unit

The Material Control Unit requisitions the raw materials and purchased parts required for the plant's production. It is responsible for initiating the screening of the supply system for available material, and for determining the component parts and their quantity to be manufactured in the plant.

In the interest of an economical material cost, the Unit, assisted by the Supply Department, investigates the required raw materials and purchased parts to determine the materials available in the extensive supply system. For this purpose the Unit originates the Firm Requirement and Obligation of Material Form, Figure 8. When the required material is available, the Unit requisitions it through the Supply Department, the procuring agency for raw materials and purchased parts.

The Production Breakdown Sheet, Figure 9, is issued by the Unit. This sheet contains information as to the quantity of each component part of a project, determined by the Unit from the parts list, prints, and an estimation of scrap and losses. The Production Breakdown Sheet, the authorization to manufacture a specific quantity of a component part, is widely distributed throughout the Production Control Division.

Also issued by the Unit is the Stub Requisition, Figure 10, for raw materials and purchased parts. It is the Unit's request for the Supply Department to procure the required raw material or purchased parts, either from the supply system or from a commercial concern.

The following diagram shows the flow of information into the Material Control Unit, the forms it originates, and the information which leaves the Unit.

FIRM REQUIREMENT AND OBLIGATION OF MATERIAL
9ND-NOP-19BS (Formerly N-473)

DATE REQUIRED | JOB ORDER | DATE | SERIAL NUMBER

ITEM NUMBER	STOCK NUMBER	DESCRIPTION	QUANTITY REQUIRED	UNIT OF ISSUE	QUANTITY OBLIGATED				PRICE PER UNIT	
					ON HAND	ON ORDER	PROC. DOC. NUMBER	DELIVERY DATE	NSA	APA

9NDGL,4-13-49,3M

Fig. 8 Firm Requirement and Obligation of Material Form

PRODUCTION BREAKDOWN
PRODUCTION CONTROL DIVISION

PUR. ORDER ON CAST..S DUE	RAW MATERIAL DUE	COMPLET... OF PROCESSING DUE
ALL PURCHASE ORDERS DUE	PURCHASED PARTS DUE	SHOP PARTS DUE

WND NCP-157 (Rev. 3 49)

BD ITEM NO.	SHIP ITEM NO.	UNIT QUAN.	PART NUMBER	PART NAME	PROJECT. ORDER QUAN.	MATERIAL SOURCE OR SPEC.	QUAN. TO PURCHASE	STUB NO.	P.O. #	VENDOR SHIP DATE	AMOUNT RECEIVED	QUANTITY TO MAKE	SHOP ORDER NUMBER	EST. HOURS	SCH. DATE	AMT. TO STORES

DELIVERY DATE	DATE L.D. REC'D.	DATE COPY SENT TO METHODS	J.O. NO.	ACCOUNTING NO.	APPROPRIATION NO.	L.O. NO.	PAGE OF

Fig. 9 Production Breakdown Sheet

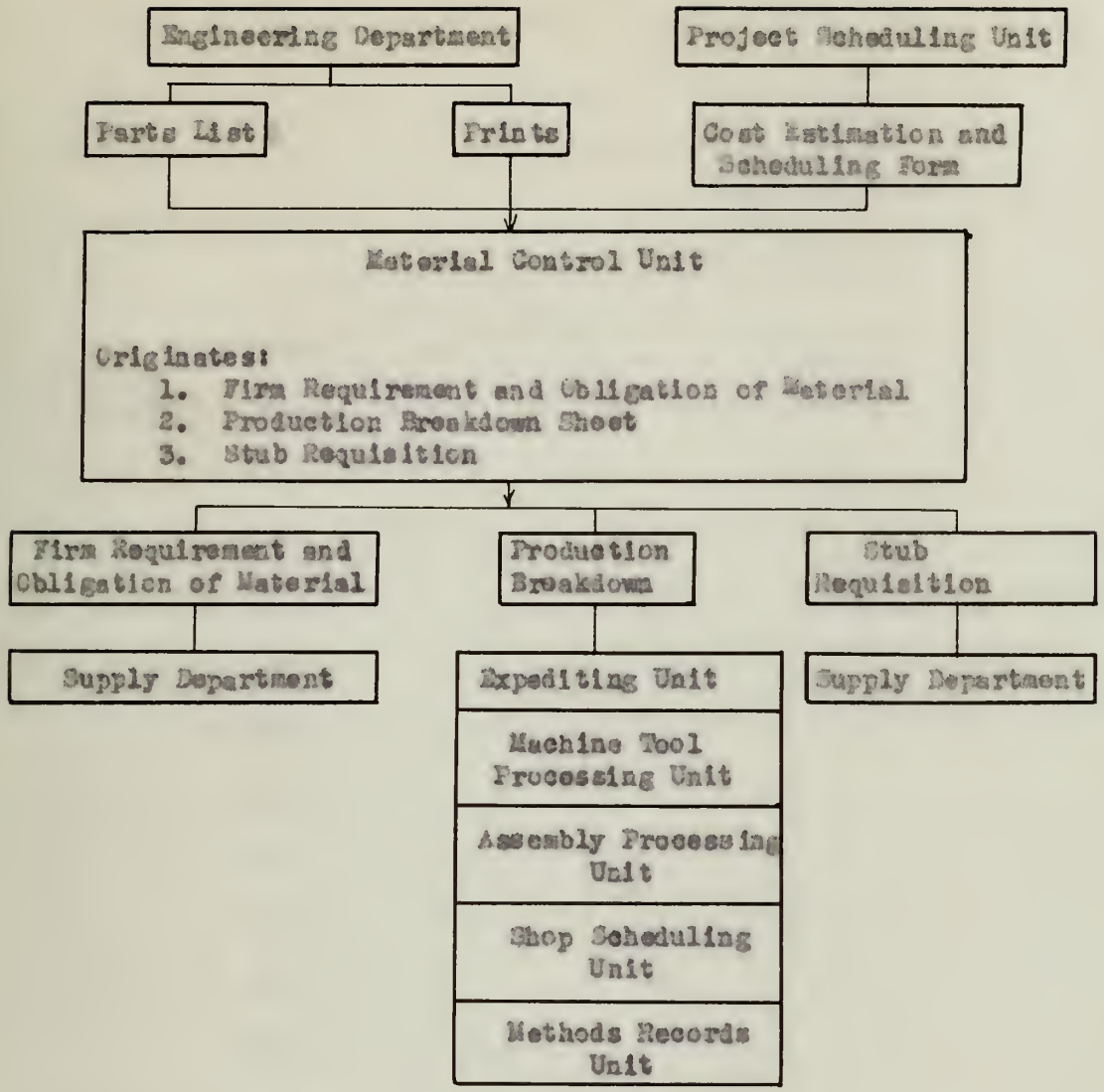
Fig. 10 Sub requisition

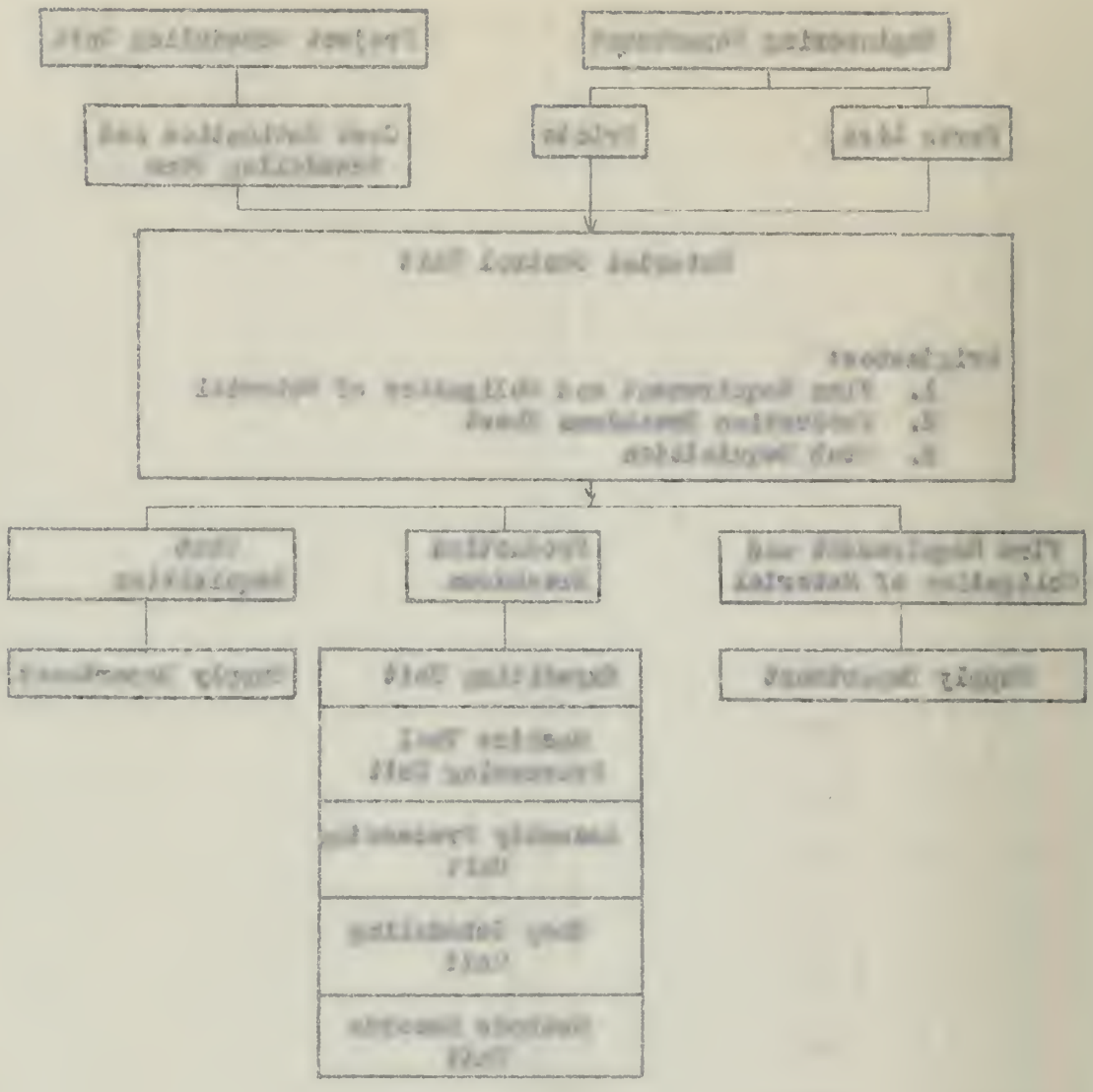
STUB NO.	SHOP	SHIP OR STATION	JOB ORDER NO.	WORK CLASS.	APPROPRIATIONS CHARGEABLE	PROJ. OR ALLOT.	OBJ. CLASS	ACCT. EX-PENDED FROM	DATE

UNIT OF ISSUE	QUANTITY	UNIT PRICE	EXTENSION		CLASS AND STOCK NUMBER	DESCRIPTION
		TOTAL			DELIVERY POINT	MISCELLANEOUS

PRIORITY INDICATOR	APPROVED BY		ISSUED BY (DATE)	REC. VOUCHER NO.	RECEIVED BY DATE SIGNATURE	
DATE DEL'Y DESIRED	SCHEDULE	LEAVE STOCK CONTROL	LEAVE STORES	LEAVE DELIVERY	DELIVER AND CHARGE AS INDICATED SIGNATURE	1

STUB REQUISITION NAV. S. AND A. FORM 129(9M) (REV. 2-48)


Engineering Department
Project Scheduling Unit
Parts List
Prints
Cost Estimation and Scheduling Form
Material Control Unit
Originates:
1. Firm Requirement and Obligation of Material
2. Production Breakdown Sheet
3. Stub Requisition
Firm Requirement and Obligation of Material
Production Breakdown
Stub Requisition
Supply Department
Expediting Unit
Machine Tool Processing Unit
Assembly Processing Unit
Shop Scheduling Unit
Methods Records Unit
Supply Department



The Machine Tool Processing Unit

The Machine Tool Processing Unit originates the operation sheet for each component part to be manufactured in the plant, and issues requests for the designing and building of the special tools, jigs, fixtures, and gages required in the manufacture of these component parts.

This unit performs the work normally assigned in industry to the Production Planning Department. The Process Routing (or operation) Sheet, Figure 11, is one of the most important records kept by a manufacturing company, representing the "know-how" in the manufacture of component parts. It is formulated from the Parts List, Production Breakdown, and Internal Schedule received by the Unit.

The Tool Design and Build Order Form, Figure 12, is originated in the Unit from the information contained in the Parts List, the Production Breakdown, and the Process Routing Sheet. It outlines in general terms the tools, jigs, fixtures, and gages which the Tooling Division designs and builds for the manufacture of the component parts.

The following diagram shows the flow of information to the Machine Tool Processing Unit, the material originated in the Unit, and the next destination of that material.

Fig. 11 Process Routing Sheet

REQUEST FOR TOOL DESIGN AND BUILD ORDER
N 485 (Rev. 11-49)

DATE

UNIT TYPE

J.O. NO.	APPR. NO.	ACCT.	B. D. ITEM	PRIORITY	DATE WANTED
S.A. NO.	MK.	PART NO.	OPER. NO.	ROUTING DATE	NO. PARTS
SHOP ORDER NO.	MACH.	UNIT NO.	MATERIAL		

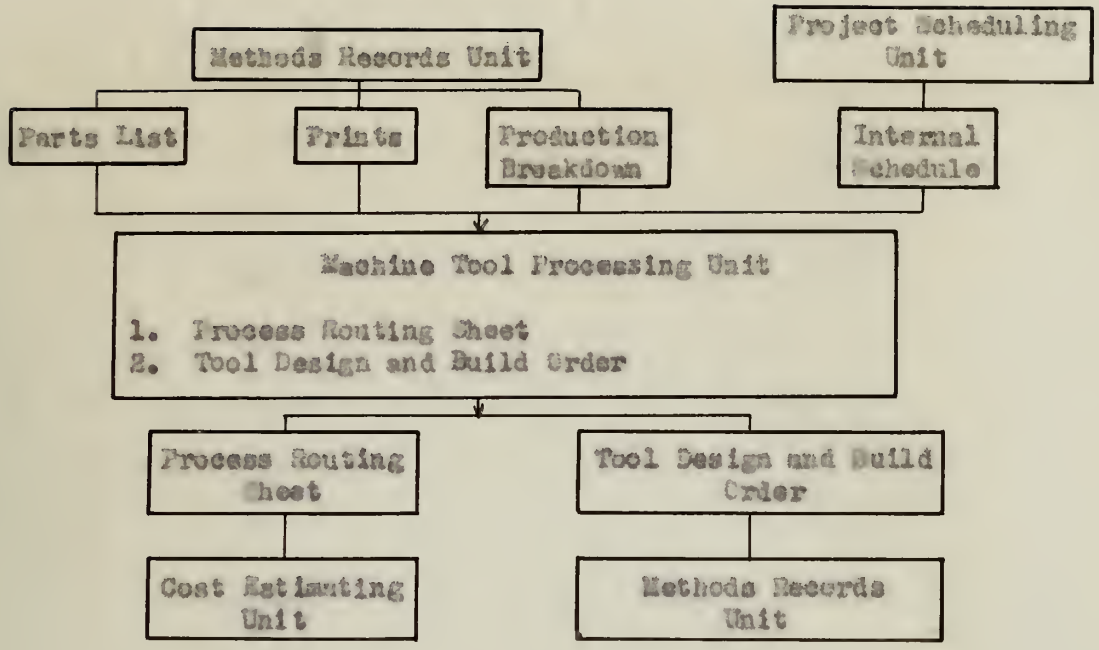
DESCRIPTION OF TOOL TO BE MADE

NOTE: Sketch of work to be done should accompany the order if possible showing critical dimensions.

DESIGN COMPLETED	REQUESTED BY	APPROVED BY

☐ NO. 1 COPY-METHODS ☐ NO. 2 COPY - TOOL DESIGN ☐ NO. 3 COPY - TOOL STORES

Fig. 12 Tool Design and Build Order Form


Methods Records Unit
Project Scheduling Unit
Parts List
Prints
Production Breakdown
Internal Schedule
Machine Tool Processing Unit
1. Process Routing Sheet
2. Tool Design and Build Order
Process Routing Sheet
Tool Design and Build Order
Cost Estimating Unit
Methods Records Unit

The Assembly Processing Unit

The Assembly Processing Unit originates the assembly operation sheet and issues orders for the tools, jigs, fixtures, gages and test equipment required for the assembly process.

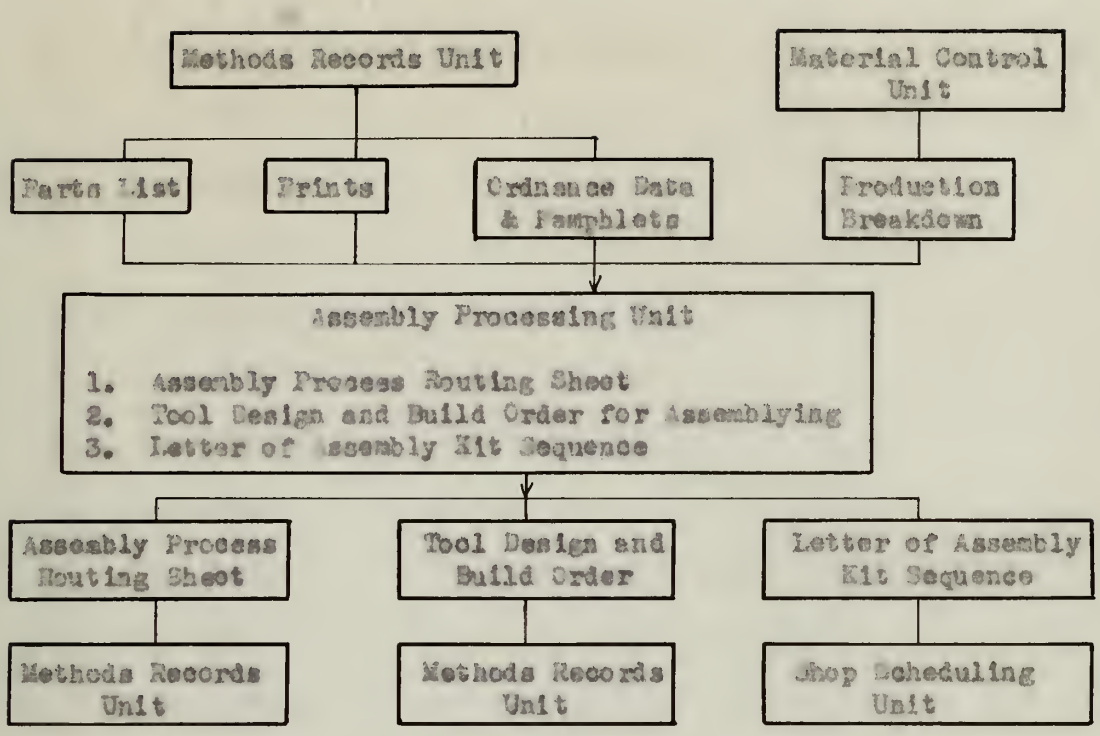
The specialization of the plant's final product, aviation fire control equipment, requires a great amount of assembly work. Since the knowledge of instrument assembly is highly technical, the Unit must provide a detailed write-up of the assembly of an aviation fire control system.

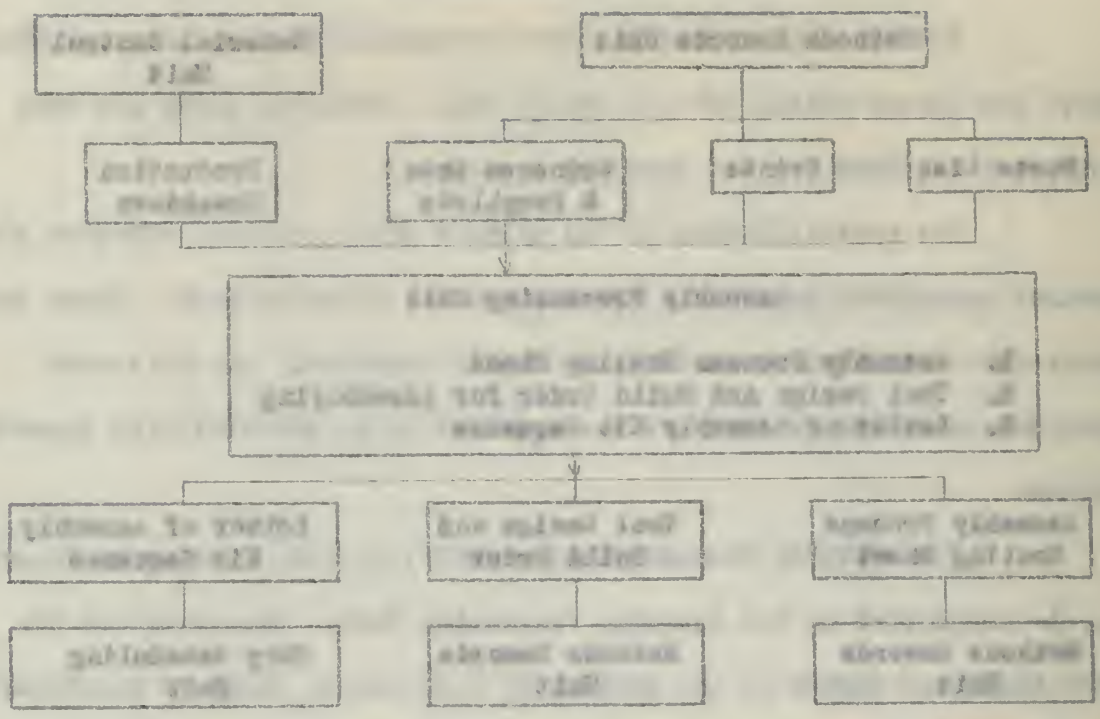
The Assembly Process Routing Sheet, in form similar to Figure 11, is originated in the Assembly Processing Unit. Experience is the most important factor in the writing of this sheet, which is constructed from the information contained in the Parts List, the Prints, and the Production Breakdown Sheet.

The Tool Design and Build Order Form, similar to Figure 12, is based on information from the Parts List, Prints, and Assembly Process Routing Sheet. The Assembly Process Routing Sheet also includes details of the required inspections; the Unit orders the special test equipment for these inspections. In some cases available commercial equipment is modified for this purpose, while in others special test equipment must be designed.

Equipment must be assembled in a definite sequence of operations; the Shop Scheduling Unit is furnished this information in the form of a letter, the Letter of Assembly Kit Sequence, which is a guide to the proper sequence of issuing the Assembly Kit.

The following diagram shows the flow of the more important information into the Unit, the material originated in the Unit, and the information departing from it.


Methods Records Unit
Material Control Unit
Parts List
Prints
Ordnance Data & Pamphlets
Production Breakdown
Assembly Processing Unit
1. Assembly Process Routing Sheet
2. Tool Design and Build Order for Assemblying
3. Letter of Assembly Kit Sequence
Assembly Process Routing Sheet
Tool Design and Build Order
Letter of Assembly Kit Sequence
Methods Records Unit
Methods Records Unit
Shop Scheduling Unit



The Cost Estimating Unit

The Cost Estimating Unit originates an estimated cost of each project undertaken by the plant, including the project's direct labor and material costs.

The component parts to be manufactured in the plant are estimated from information received from the Material Control Unit and other sources. The Cost Estimate Work Sheet, Figure 13, is used to compile data and compute total costs; this information is transferred to the Cost Estimation and Scheduling Form.

Probable operations and the time required for each are estimated by the Unit. The Machine Tool Processing Unit and the Assembly Processing Unit assist in the estimation of the operations required for the manufacture of each component part. This data is entered on the Estimate Routing Sheet, Figure 14.

The time in man-hours required for each operation, including the machine tool set-up time is estimated from past experience by the Unit.

As an aid to the maintenance of an accurate estimate of labor time required for each operation, the Unit records the actual time required at the completion of the job. With this information available, the Unit is able to keep current the time estimates in relation to the actual operation time. The estimated times are recorded on the Cost Estimate Work Sheet and the Process Routing Sheet.

The Unit keeps the Material Cost Card, Figure 15, for the purpose of estimating the project's material cost. Information from the purchase orders, which contain the current cost of materials, is transferred to the Material Cost Card which furnishes an up-to-date

9ND-NOP-286

COST ESTIMATE WORK SHEET

SHEET OF SHEETS PARTS LIST NO. PROP. NO. PJO NO. P. OR R NO. DATE

ITEM	PART NUMBER	DESCRIPTION	MAKE OR PUR.	QUANITY	MATERIAL COST				STD. TIME PER PIECE		DIRECT LABOR COST			
					FABRICATED		PURCHASED		ASSEMBLY	MACH. TOOL	ASSEMBLY @		MACHINE TOOL @	
					UNIT	TOTAL	UNIT	TOTAL	UNIT HR.	UNIT HR.	UNIT	TOTAL	UNIT	TOTAL

ESTIMATE ROUTING

MATERIAL ______________________ SHEET ________ OF ________

PURCHASED MATERIAL COST ________ PART NO. ______________

FABRICATED MATERIAL COST ________ PART NAME ______________

G.U.N. ON
WHICH SET-UP IN PRORATED ________ ASSEMBLIES INTO ______________

PROPOSITION NO. ______________

OPER. NO.	MACH CODE	DESCRIPTION OF OPERATION	SET UP TIME	OPER. TIME
N-207	R1			

Fig. 14 Estimate Routing Sheet

Fig. 18 Material Cost Card

MATERIAL COST CARD

PART NUMBER_____

PURCHASE ORDER	DATE	QUANTITY	DESCRIPTION	UNIT PRICE

9ND-ORD 187 (Formerly N-302) 9ND GL, 6-13-47, 200

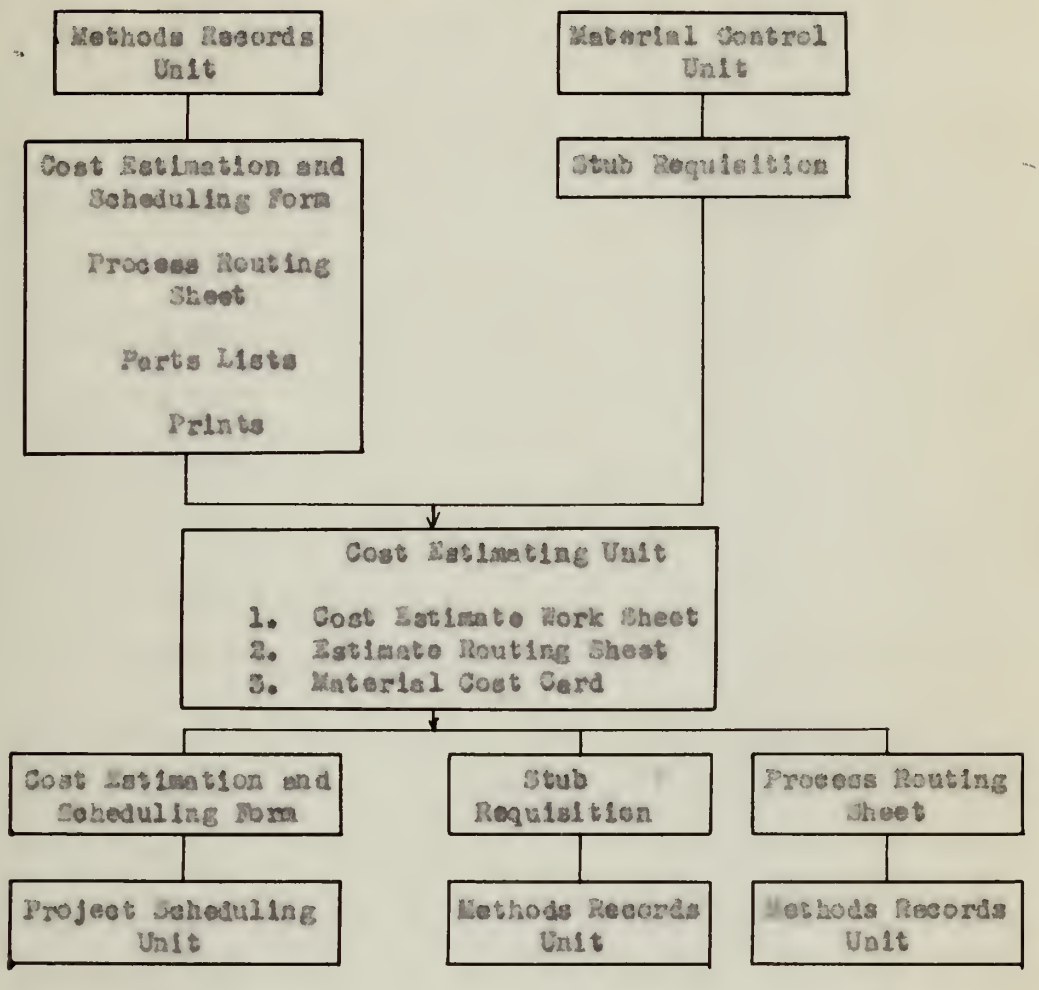
MATERIAL COST CARD

PART NUMBER _____

PURCHASE ORDER	DATE	QUANTITY	DESCRIPTION	UNIT PRICE

record of material costs for the Unit.

The following diagram shows the flow of information into, through, and out of the Cost Estimating Unit.



The Shop Scheduling Unit

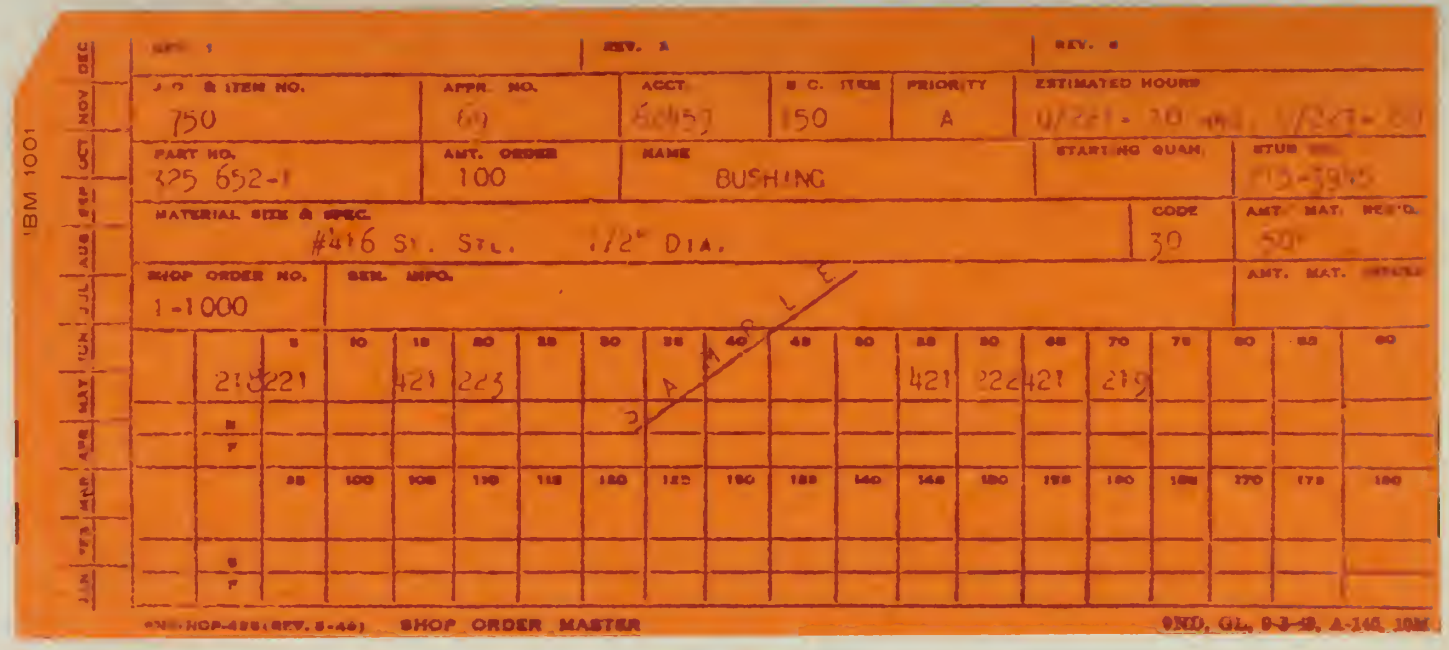
The Shop Scheduling Unit assigns to the Machining Division the manufacture of the component parts and to the Assembly Divisions the assembly of these parts into completed items. The Unit maintains a current record of work load in man-hours, which forms the basis for the addition of new work to the shop.

Figure 16 shows the Shop Order Kit, the shop's authority to manufacture a component part on assembly. This form is compiled from information contained in the Process Routing and Production Breakdown Sheets and the Internal Schedule Form. The required month date of the component part's completion is given on the Shop Order Kit. The shop is thus scheduled for work by months in terms of man-hours. The Shop Order Kit consists of eight vari-colored IBM cards, each color having a specific usage. The yellow material identification card is the master card, accompanying the shop order from raw material to completed component part; the green card is the material requisition card, etc.

The Weekly Machine Load Summary, Figure 17, is issued by the Unit. It serves as a means of determining the relative operating efficiency of the various units of the Production Division, and is the basis for adding new work to the shop and adjusting potential man-hours of labor between the Production Divisions. This report contains information on the number of man-hours released to and completed by the shop, and the present amount of work available for the shop.

The Unit issues the Assembly Monthly Schedule which establishes the sequence of work to be accomplished by the Assembly Division during a month. Since there are many unpredictable time-consuming variables in the assembly of a highly complex instrument, the Assembly

FIG. 16 SHOP ORDER MIS



IBM 1001

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

REV. 1 | REV. A | REV. B

J. O. & ITEM NO.	APPR. NO.	ACCT.	B. C. ITEM	PRIORITY	ESTIMATED HOURS
750	69	60453	150	A	4/221 - 20 hrs. 4/223 - 80

PART NO.	AMT. ORDER	NAME	STARTING QUAN.	STUB NO.
325 652-1	100	BUSHING		713-3945

MATERIAL SIZE & SPEC.	CODE	AMT. MAT. REQ'D.
#416 St. Stl. 1/2" DIA.	30	50'

SHOP ORDER NO.	SER. NUMBERS	AMT. MAT.
1-1000		

		5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
		215 221		421	223							421	222	421	219				
	S						3												
	F																		
		95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180
	S																		
	F																		

NAVSHOP-495 (REV. 5-46) SHOP ORDER MASTER 9ND, GL, 9-3-48, A-145, 10M

N405 R1 (800)

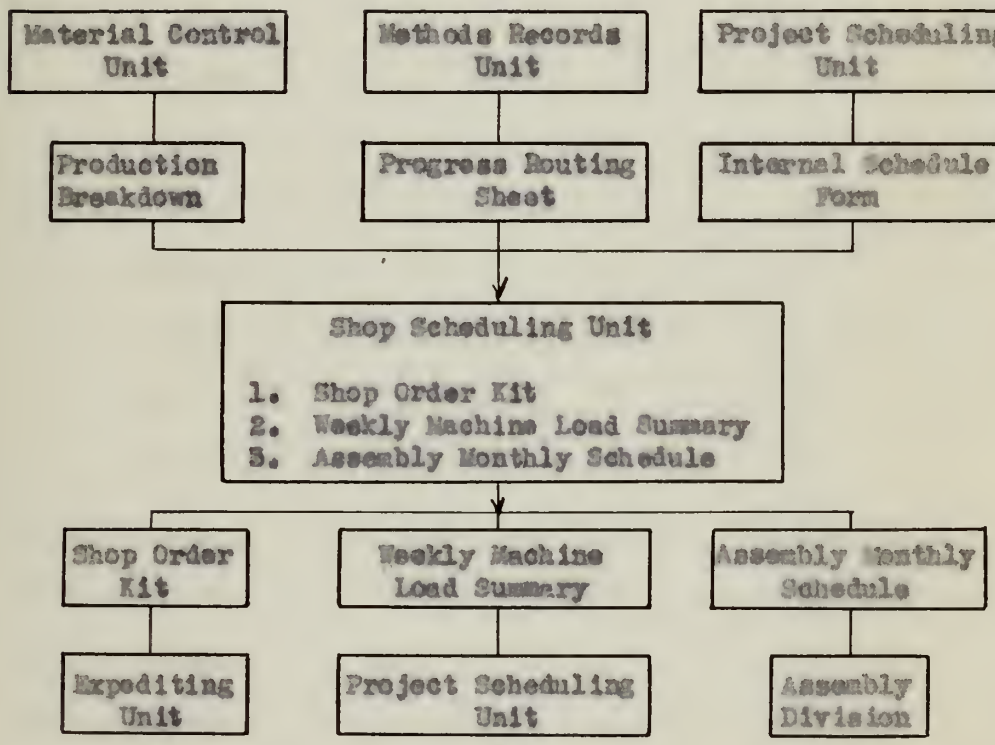
WEEKLY MACHINE LOAD SUMMARY

P.J.O.	TOTAL HOURS ASS'G'D	ASS'G'D DURING WEEK	TOTAL COMP TO DATE	HOURS COMPLETED 1 WEEK				U.H. = UNSCHEDULED HOURS, S.H = SCHEDULED HOURS							
				D/221	D/223 D/225	D/224	TOTAL	D/221		D/223 D/225		D/224		TOTAL	TOTAL
								U.H.	S.H.	U.H.	S.H.	U.H.	S.H.	U.H.	S.H.

Fig. 17 Weekly Machine Load Summary

Division is not scheduled for work in terms of man-hours per month. The probable time required is available in a rough estimate, from which data the Assembly Monthly Schedule lists the projects' priorities and the required monthly delivery rates of the assembly units. Normally the Assembly Monthly Schedule overloads the Assembly Divisions in terms of man-hours of assembly work.

The important forms received in, originated by, and sent from the Unit appear below.



The Expediting Unit

The Expediting Unit is charged with the responsibility of seeing that the materials for a shop order are located physically in the plant prior to sending the shop orders to the shop and that all shop schedules are met. The Expediting Unit initiates suggestions for substitute materials, and originates requests for new work to replace the "rejects" on job orders.

In order to prevent confusion in the shop, Shop Order Kits are not released for manufacture until the necessary raw materials for them have been received in the plant.

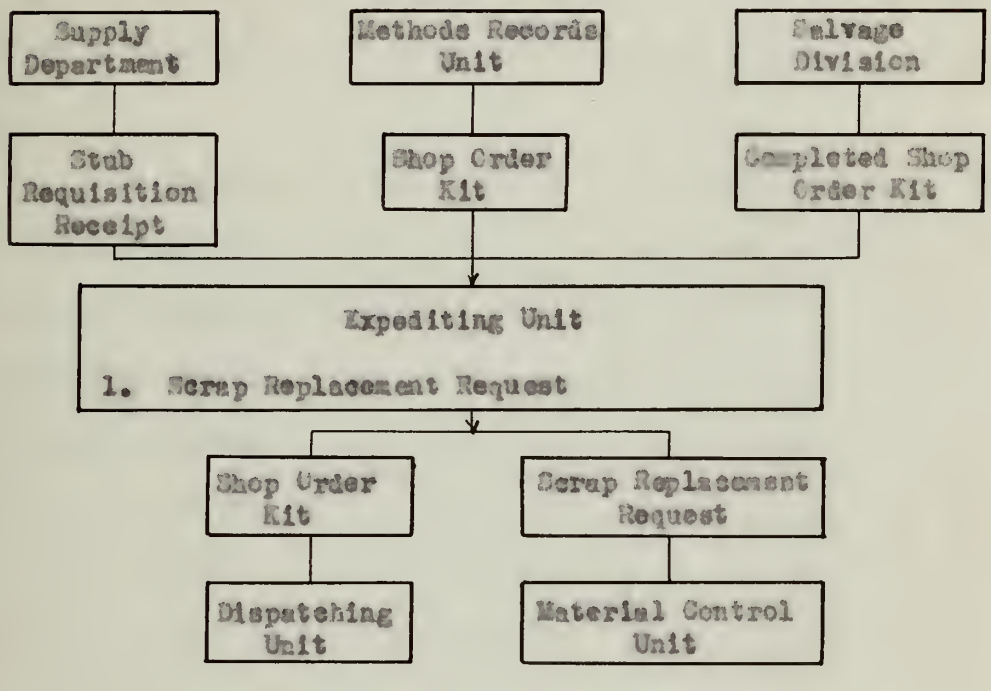
After receiving the Shop Order Kit from the Methods Records Unit, the Expediting Unit holds the kit until the Stub Requisition Receipt is received. This receipt is issued by the Supply Department after the material has been received. The Unit maintains a record of all Shop Order Kits and the required material for each; it also makes a weekly check of all kits being held up because of a lack of materials. A bi-monthly record of all such held-up kits is sent to the Head of the Production Control Division. The Unit expedites the procuring of materials through the Supply Department. In some cases, the Unit originates a substitute material upon the approval of the Methods Section or the Engineering Division. In other cases, such a suggestion for substitutes comes from the shop or the Supply Department; the Unit is responsible for having these suggestions approved by the Methods Section or the Engineering Division.

When parts are rejected by the Inspection Division and scrapped by the Salvage Division, the information is recorded on the back of the Master Card in the Shop Order Kit. After the Expediting Unit receives

The Embodied Self is changed when the relationship is terminated that the existence of the body changes. The importance is associated to the body if the body is changed. Some people are relieved by the termination that a relationship with the Significant Other. Individuals express a relationship the support. Individuals who have a relationship with the Significant Other. Individuals who have a relationship with the Significant Other. Individuals who have a relationship with the Significant Other

the Master Card, it originates a "scrap replacement request." This form is sent to the Material Control Unit, after which it is handled in the same manner as the original Shop Order Kit.

A general work flow diagram of the Expediting Unit is shown in the chart below.



The Dispatching Unit

The Dispatching Unit is responsible for the releasing of work to the shop and assembly divisions in accordance with the schedule. The Unit performs "trouble-shooting" activities to coordinate the materials, machine tools, and work for the Production Division. The records charting the progress of the assigned work are kept by the Unit. The material handling problems of the plant are also a responsibility of the Dispatching Unit.

The Shop Order Kit is received from the Expediting Unit, and, with the exception of the Material Requisition Card, the kit is placed in the appropriate pocket board. The pocket boards are arranged by Machining and Assembly Units by months. The Shop Order Kit is taken from the pocket board by the Head of the Unit, who establishes the sequence of work in his unit, based upon the completion date on the Shop Order Kit. To start a new job, the operator obtains the Material Requisition Card from the Dispatching Unit, and draws the required material. The Unit assists in the movement of materials from the storeroom to the workplace. The Unit transfers the partially completed job to the next scheduled Unit, and the Shop Order Kit to the appropriate pocket board of the next scheduled Unit. Thus, the location of the Shop Order Kit in the pocket board serves as a progress record of the job. The high priority Shop Order Kits are designated by a special color code, and these jobs are given special expediting attention.

The Dispatcher's File Card, Figure 18, is used to record progress of the shop orders and tool shortages. The Unit makes a daily floor check, gathering the data on the operations on the jobs in process. This data is recorded on the Dispatcher's File Card.

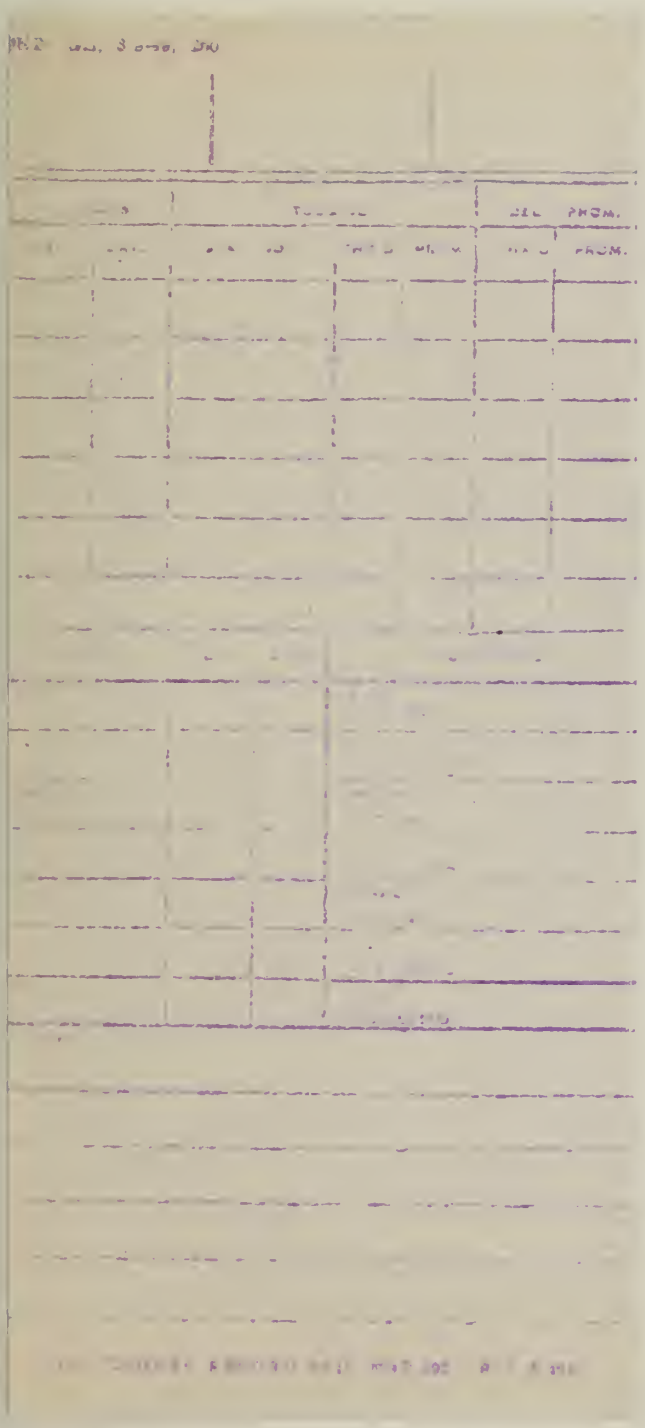


Fig. 18 Dispatcher's File Card

The Tool Shortage Report, Figure 19, is a report to the Tool Division, listing the jobs being held up because of a lack of tools. This report is submitted weekly, and its information is derived from the data gathered on the daily floor checks.

The flow of information into, the originated forms, and the forms departing from the Unit are shown in the diagram below.

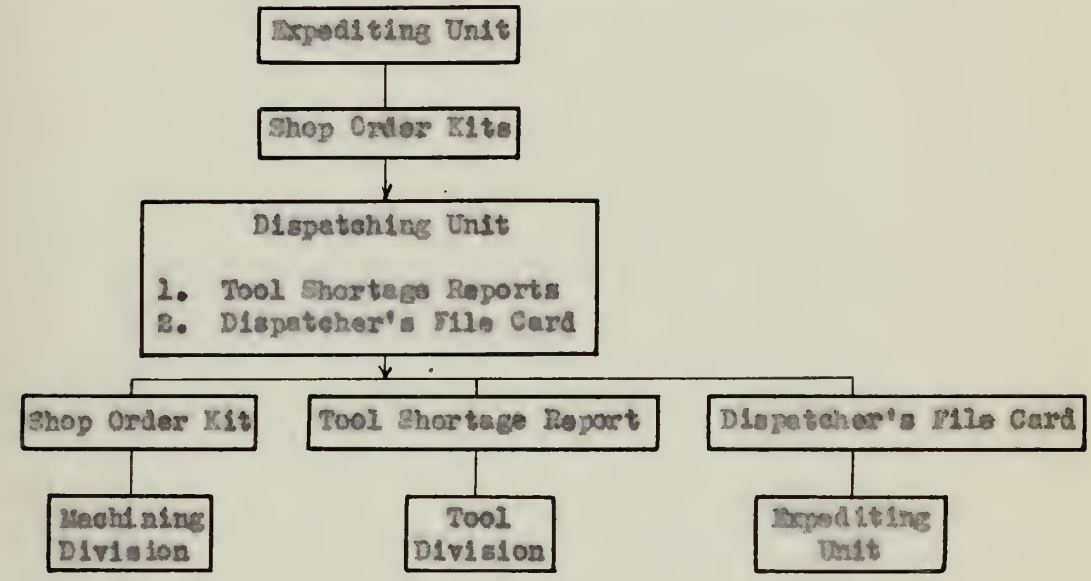


Fig. 19 Tool Shortage Report

TOOL SHORTAGE LIST _____

PJO	PART NUMBER	PART SCHEDULE DEL. DATE	S.A. NUMBER	NEW	RE-WORK	TOOL ORDER REL. DATE	TOOL SCHEDULE DEL. DATE	TOOL PROMISE DEL. DATE	REMARKS

BY _____

cc: H. Evans
R. Kurtz
W. Bates
A. McQuistan
Disp. File

The Cost Control Unit

The Cost Control Unit records the commitment and expenditure of funds for the various productive projects, and analyzes estimates and expenditures to aid in locating discrepancies. The overhead budget for the Industrial Department is prepared by the Cost Control Unit.

The Job Order Cost Control Record, Figure 20, is maintained by the Unit, information being transferred to this record from the Stub Requisition, Purchase Orders, Public Vouchers, and Closed Shop Order Tabulations. This record is an accumulative financial sheet giving the amount of funds available, the amount expended to date, and the amount remaining for the job. Also shown is the variance between the estimated and the actual cost of each job order, as well as the accumulated variance.

The Request for Revision of Job Order Estimates is in the form of a letter, used to request additional funds for a job order when it is apparent from the Job Order Cost Control Record that the allotted funds are not sufficient. This request is sent through the Head of the Production Control Division to the plant's administration.

Also in the form of a letter, the Shop Order Report is submitted to the Cost Estimating Unit and the Machining Division, showing the variation between the estimated and actual labor hours of the shop order. This report presents variance data to be investigated by the Cost Estimating Unit and the Machining Division. Information contained in the Shop Order Report is taken from the Job Order Cost Control Record.

The Request for Station Maintenance Funds for the Industrial Department, Figure 21, is made up by the Unit from information contained in the Department Budget Report, the Leave Analysis Report, and the Tabu-

COMMITMENT COSTS JOB ORDER COST CONTROL FISCAL COSTS

ORD.			DESCRIPTION									DATE			
CARD	REFERENCE	DATE	LABOR ITEMS	MATERIAL ITEMS	TOOLING ITEMS	TOTAL CUMULATIVE	DIFFERENCE ITEMS	CARD	REFERENCE	DATE	LABOR ITEMS	MATERIAL ITEMS	TOOLING ITEMS	TOTAL CUMULATIVE	DIFFERENCE CUMULATIVE

9ND-NOP-299(Formerly N-266 R2) 9NDGL, 7-17-47, 1500

Fig. 20 Job Order Cost Control Record

Fig. 21 Request for Station Maintenance Funds

REQUEST FOR STATION MAINTENANCE FUNDS

DEPARTMENT_____ MONTH OF_____

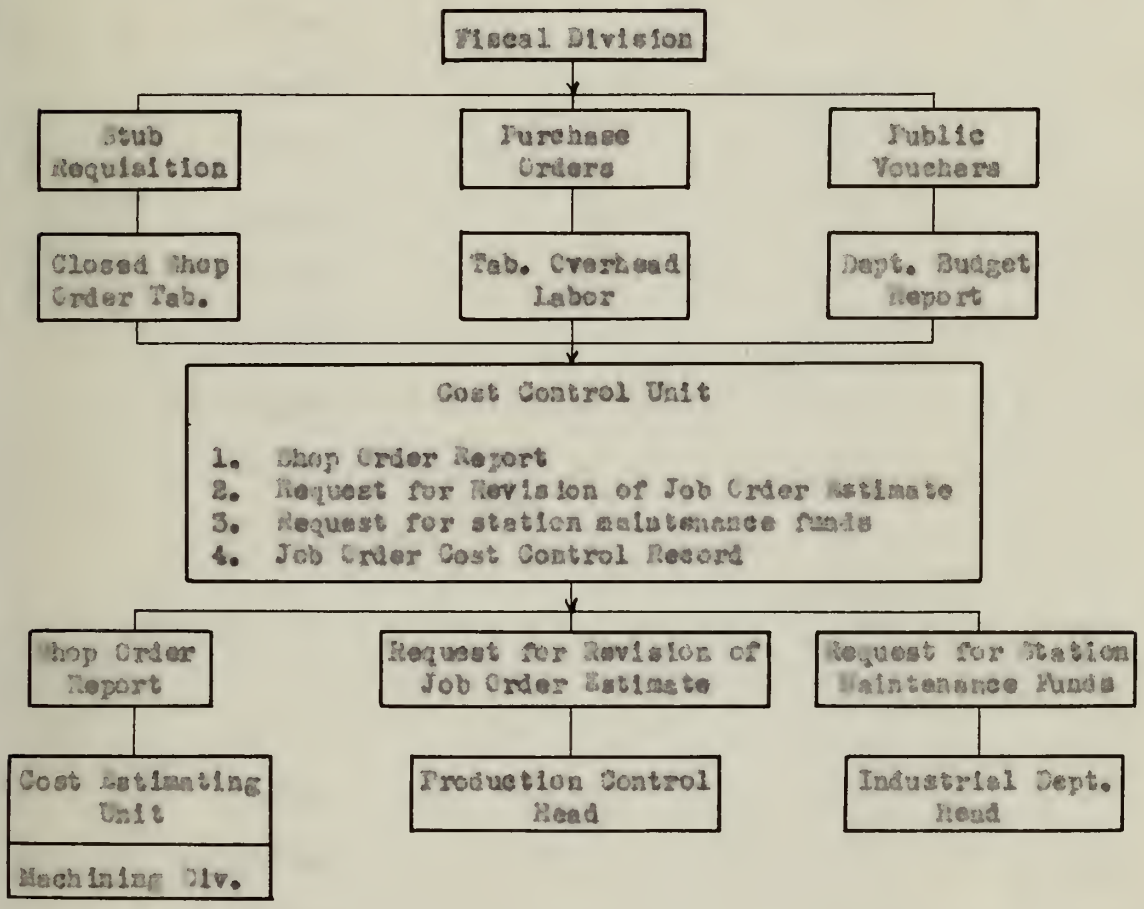
	IVB	PER DIEM	TOTAL
1. No. of persons used in computation			
A. Non-productive personnel			
B. Productive personnel			
2. Number of work days in month			xxxxx
3. Number of holidays in month			xxxxx
4. Current average daily wage rate			xxxxx
ESTIMATED COSTS			
5. Non-productive personnel wages			
6. " " " overtime			
7. " " " terminal leave			
8. TOTAL COST NON-PRODUCTIVE PERSONNEL			
9. Productive personnel Annual and Sick Leave			
A. (Based on __% of productive personnel pay)	xxxxx	xxxxx	xxxxx
10. Productive personnel holiday pay			
11. " " terminal leave pay			
12. TOTAL COST PRODUCTIVE PERSONNEL			
13. Miscellaneous labor costs			
14. TOTAL MISCELLANEOUS LABOR COST			
15. TOTAL ESTIMATED LABOR COST			
16. ESTIMATED MATERIAL COST	xxxxx	xxxxx	
17. GRAND TOTAL OF REQUEST			

_____
Department Head

REMARKS:

lation Overhead Labor Report. This request consists of estimates of the required overhead funds for the Industrial Department.

The following diagram shows the flow of information into the Unit, the material originated therein, and the next destination of that material.



The Production Stores Unit

The Production Stores Unit composed of the Finished Parts Stores, Semi-finished Parts Stores, and Raw Material and Casting Stores is charged with the responsibility of receiving, storing, and issuing all production material in process of manufacturing. This material includes raw stock, purchased parts, and manufactured parts, either semi-finished or finished.

Purchased parts or raw material coming into the Unit from the Supply Department are accompanied by a copy of a Stub Requisition. Material or parts manufactured in the plant are accompanied by the Yellow Shop Order Master Card from the Shop Order Kit. All incoming material or parts are identified as to the project number to which they apply, the part number, the Stub number of Shop Order number, depending on how received, and the quantity received. The material or parts are then stored in the area allocated for that particular project or as dictated by the form of the material (such as raw material in big sheets). Information is taken from the Stub Requisition and the Shop Order Master Card to record the location of the material on the Finished Parts Locator Record, Figure 22, and to act as additional information for the cross-reference file. This information is also used to make the appropriate entries on the Commitment and Stores Record Cards, Figure 23. This record acts as the balance of stores ledger used in a large number of business concerns. The cross-reference file spoken of is maintained in order to facilitate the shifting of material or parts from one project to another when applicable. However, such shifting must be cleared by the Expediting Unit prior to the shift. The Finished Parts Locator Record, mentioned above, is used as a means of quickly locating any part

Fig. 23 Finished Parts Locator Record

PART NO. .....

PJO NUMBER	AMOUNT REC'D	BIN LOCATION	DATE REC'D

FINISHED PARTS LOCATOR RECORD 9ND-NOP-1748, K-41 Navy—DPPO 9ND, Great Lakes, Ill.

COMMITMENT									STORES				
REQUIREMENTS				PROCUREMENT DATA									
P.J.O. NO.	F.L. NO.	QUANTITY	CUMULATIVE TOTAL	DATE	ORDER NO.	QUANTITY	CUMULATIVE TOTAL	PLUS OR MINUS	DATE RECEIVED	AUTHORITY NUMBER	IN	OUT	BALANCE ON HAND

PART NUMBER	PART NAME	MAXIMUM	MINIMUM

COMMITMENT AND STORES RECORD 9ND-ORD-IND-140 (Formerly N-293) 9NDGL-6-17-47-12M

Fig. 23 Commitment and Stores Record Card

stored in the Unit.

The majority of the issuing of parts and material is done on authority of the green Shop Order Master Card and the transaction is conducted in the reverse order as explained for incoming parts or material.

AN EVALUATION OF THE PRODUCTION CONTROL PROCEDURES AT THE NAVAL ORDNANCE PLANT INDIANAPOLIS

Definition of Production Control

Production Control may be defined as "the mental and physical techniques and procedures employed to the end that the right quantity and quality of a product shall be produced at the right time by the best and cheapest methods."[2]

Criteria for Evaluation

There is a wide diversity of opinion in the literature on production control as to the functions which should be included in a production control procedure. The functions listed below represent some of those appearing in most of the texts of the Bibliography.

1. The preparation and issuance of production orders and forms such as work orders, time cards, move orders, materials issue slips, tool issue slips, etc.
2. Purchase requisitioning to obtain raw materials and special items bought outside
3. Preparation of route sheets
4. Work scheduling
5. Plant loading
6. Work dispatching
7. Determination of the labor requirements
8. Maintenance of production records
9. Expediting of manufactured and purchased items
10. Analysis of idle machine time

---

[2] Bethel, Lawrence L.; Tsun, Walter L.; Atwater, Franklin S.; Kung, Edward S., Production Control, McGraw-Hill Book Company, Incorporated, 1948, pp. 2.

[illegible]

[illegible]

[illegible]

Discussion

It is understood that not every production control procedure will include all of these functions, and that some procedures may include others not listed here. For the purpose of this evaluation, an analysis of the production control procedure at [illegible] has been conducted to determine how the functions listed above are accomplished; whether or not improved means of accomplishing the functions can be recommended; and if the functions are not accomplished, whether or not it is deemed advisable to perform the functions.

The Preparation and Issuance of Production Orders and Forms. The function of preparing and issuing production orders and forms is shared by most if not all of the units of the Production Control Division at the plant. The several units prepare and issue the orders and forms that are applicable to their primary functions. The units and the forms they originate and issue are very briefly described below:

1. Material Control Unit originates and issues the following:
   A. The Stub Requisition, used to requisition raw materials and purchased parts
   B. The Firm Requirement and Obligation of Material Form, used as a means of screening the supply system for parts needed on a project
   C. The Production Breakdown Sheet, establishing the quantity of a component part to be manufactured
2. Project Scheduling Unit originates and issues the following:
   A. The Internal Schedule, establishing the completion date of each project
   B. The Forecast of Productive Labor, establishing the over-all

production schedule of the plant

C. The Man Load and Performance Chart, an efficiency standard for the shop, showing the amount of work completed by the shop against the amount of work released to the shop

D. The Monthly Man Load Summary, a report including the utilization of man-hours for the past month, recommended inter-divisional transfers of personnel, and status of current projects

3. The Shop Scheduling Unit originates and issues the following:

A. The Shop Order Kit, the authority upon which the shop starts, processes, and completes a job

B. The Weekly Machine Load Report, indicating the amount of work released to, completed by, and currently available to the shop

C. The Assembly Monthly Schedule, a monthly schedule indicating priority on projects to be assembled

4. The Dispatching Unit originates and issues the following:

A. The Dispatcher's File Card, used to record tool shortages and the progress of the shop orders

B. The Tool Shortage Report, used to indicate what jobs are being held up because of the lack of tools

5. The Expediting Unit originates and issues the following:

A. The Scrap Replacement Request, used to originate the work necessary to replace parts that have been rejected or scrapped

The function of preparing and issuing production orders and forms is accomplished at the plant in such a manner as to aid and facili-

tate the service rendered the production divisions. The present distribution of the responsibility for preparing and issuing the orders and forms is the result of various changes in the system through continuous investigations seeking improvement.

Purchase Requisitioning. The function of originating and issuing purchase requisitions to obtain raw materials and purchased items is accomplished by the Material Control Unit in the form of a Stub Requisition. The Unit receives the Parts List, the Prints, and the Cost Estimating and Scheduling Form. From this information, the Unit issues the Production Breakdown Sheet which establishes the quantity of the various component parts. This established quantity includes the Unit's estimation for scrap and losses. Using the Production Breakdown Sheet as a guide, the Unit investigates the Supply catalogues to ascertain whether the required material is listed as a stock item. If the required material appears in the catalogue, the items are listed on the Firm Requirement and Obligation of Material Form, originated by the Unit and sent to the Supply Department. The Supply Department processes these items to determine the availability, location, cost, and estimated delivery date of the materials. This information is recorded on the Firm Requirement and Obligation of Material Form which is then returned to the Material Control Unit.

Upon receipt of this form and if the Supply Department has indicated that it is able to furnish the required materials by the date desired, the Unit requisitions the materials from the Supply Department by Stub Requisition. If the Supply Department is unable to furnish the required materials from the available supplies, the Unit issues a Stub Requisition authorizing the purchase of the required materials from a

civilian concern. This Stub Requisition is also sent to the Supply Department, the procurement agency for all materials.

It seems inevitable that government supervision brings with it a time-consuming complex system of material procurement. The very nature of federal direction of a plant necessitates more "red tape" than private industry encounters. The system of material procurement at NOPI, however, reduces the complexities of government regulation to a minimum, and accomplishes the job in the shortest possible time with a maximum of personnel economy. The fact that NOPI employs men well versed in the intricacies of government regulations contributes a great deal to the efficient functioning of purchase requisitioning at the plant.

The Preparation of Route Sheets. The preparation of the route sheet is accomplished by the Shop Scheduling Unit by the issuing of the Shop Order Kit. The Unit receives the Process Routing Sheet and the Production Breakdown Sheet, and maintains a load chart in terms of man-hours for each Machining Unit. The routing of a component part is established by the Unit from information contained in the Process Routing Sheet, which indicates the type of machine that is to perform the operation, and in the load chart giving the load of the Machining Units. Thus, the routing is performed in terms of Machining Units, whose designating numbers are placed on the Shop Order Kit corresponding to the listed operation numbers.

The designation of the specific operator and machine for each operation is accomplished by the Head of a Machining Unit.

The above procedure for the preparation of the route sheet fulfills the needs of the shop at NOPI. The routing is based upon the

man-hour method of loading the shop. This basis is used because the available man-hours of labor is the limiting factor in the plant's productive capacity. The wide dissimilarity of the plant's products makes it necessary for the head of a machining unit to determine individually the specific operator and machine that should perform a certain job. In many cases, the required machining tolerance of a job is such that only a specific operator using a specific machine can accomplish the work. The head of a machining unit, from past experience, is able to assign such operators and machines for a specific job far better than could the Production Control Division were such a detailed routing procedure attempted.

From the point of view of the needs of the shop and minimum overhead expense in accomplishing the preparation of the route sheets, the procedure used at NOFI is excellent.

Work Scheduling. The responsibility of scheduling work is shared by several units in the plant. The Forecast of Productive Labor form is originated by the Project Scheduling Unit, establishing the over-all production schedule of the plant for approximately eighteen months in the future. A new project is coordinated into this over-all schedule by the Unit with a proposed delivery date determined. Using this delivery date as a goal, the Unit then makes up an Internal Schedule on the project. This is passed on to the Shop Scheduling Unit to serve as the basic schedule for the various component parts. The Shop Scheduling Unit determines the completion date required for each component part according to the requirements of sub-assembly schedules, machining time required on sub-assemblies prior to final assembly, etc. This adjusted completion date is placed on each Shop Order Kit (one for each

component part). When the Shop Order Kits are received by the Dispatching Unit, they are placed in the pocket board pertaining to the Machining Unit indicated on the Kit as that Unit by which the part is first machined. The Head of each Machining Unit takes the cards from the appropriate pocket board and, after considering the completion dates indicated on the Shop Order Kits, he establishes the sequence in which the jobs will be processed.

The critical factors of a ceiling on personnel and the necessity for loading the plant by man-hours make this the best type of scheduling for the plant's needs. The actual "when" in terms of a certain day or hour on which a part is to be started has to be determined by someone (in this case, the Head of the Machining Unit) who is in direct contact with and has charge of the men in the Machining Units.

The system of scheduling as practiced at the plant is basically similar to the accepted practice in most commercial concerns. It is felt that the scheduling has to be done in this manner to coordinate adequately into the over-all plant schedule all the many dissimilar projects that are allocated to the plant for production.

Plant Loading. The function of plant loading is accomplished by the Project Scheduling Unit and the Shop Scheduling Unit. The plant is loaded in terms of man-hours of labor per month. The Project Scheduling Unit issues the Forecast of Productive Labor, a chart displaying the over-all plant production forecast in terms of man-hours, projected eighteen months ahead. Various new projects are added to the plant's load schedule based upon the required delivery dates of the Bureau of Ordnance. From this load schedule, for each new project, the Project Scheduling Unit processes a Cost Estimation and Scheduling Form which

shows the expected monthly delivery rates of the project. Based on these delivery rates, the Unit issues the Internal Schedule which shows the completion dates of the various sub-assemblies.

The Shop Scheduling Unit maintains a load chart in man-hours by Machining Units. From the information contained in the Internal Schedule, the Shop Scheduling Unit loads the Machining Units to capacity.

To record the completion of work for the purposes of adjusting the above loading procedure, the completed Shop Order Kits are returned to the Shop Scheduling Unit which in turn removes the completed work from the load chart. The Unit issues the Weekly Machine Load Report which contains the number of man-hours completed by and the present amount of work available for each Machining Unit. This report is received by the Project Scheduling Unit which makes the proper adjustments to the Internal Schedule, the Cost Estimation and Scheduling Form, and the Forecast of Productive Labor.

Since the function of plant loading is closely integrated with the functions of preparation of route sheets and work scheduling, the procedure of plant loading at NOPI is performed by the same personnel. The system permits great flexibility, a factor necessary in an organization producing equipment subject to continuous change.

Work Dispatching

The function of work dispatching is done by the Dispatching Unit of the Production Control Division. The Shop Order Kit, the authority for all work done in the shop, is received by the Dispatching Unit from the Expediting Unit. The kit has a notation on the master card indicating the month of completion. The Dispatching Unit takes all the cards in the kit and perforates the indicated month of completion on the small

calendar across one end of the card. The kit now indicates to anyone who handles any of the cards just when the part is due for completion. The Dispatching Crib contains several pocket boards, arranged by Machining Units and months. The kit, minus the Material Requisition Card, is placed in the appropriate pocket board of the Machining Unit scheduled for the first operation. The Shop Order Kits are taken from the pocket board by the Head of the Machining Unit, who arranges the sequence of the Shop Order Kits, and issues them to the operators. The operator first goes to the Dispatching Unit to obtain the Material Requisition Card in order that he may procure the necessary materials. This gives the Dispatching Unit the commencement date on the Shop Order Kit which is recorded on the Dispatcher's File Card.

The Shop Order Kit consists of various colored IBM cards. As has been indicated above, among these cards is the one for material requisitioning. Also included in the kit is the tool requisition card (the brown card). Three very necessary functions of Dispatching have thus far been accomplished, and they are the releases of the work order, the material, and the tool requisitions.

When the operations scheduled for a Machining Unit are completed, the work piece and the Shop Order Kit are returned to the Dispatching Crib. The Shop Order Kit is placed in the pocket board of the next scheduled Machining Unit, and the work piece is stored in the vicinity of the Dispatching Crib. This procedure is repeated until the job is completed, at which time the Shop Order Kit is closed out and the yellow master card returned to the Shop Scheduling Unit.

Approximately eighty-five percent of the work on one component part is accomplished by one Machining Unit; thus only about fifteen per-

cent of the work must pass through the Dispatching Crib a second time. In order to prevent the loss of time, additional material handling, and traffic jams in the Dispatching Crib area for this fifteen percent of the work, it is recommended that the material handlers be instructed to transport the work pieces and Shop Order Kits directly to the next scheduled Machining Unit, informing the Dispatching Crib of the move.

The status of the various jobs is indicated by the location of the Shop Order Kit in the various pocket boards, and the information recorded on the Dispatcher's File Card. As mentioned above, during the process of performing the sequence of operations required on a component part by each successive Machining Unit, the Shop Order Kit is progressing to and from the pocket board corresponding to the same Machining Units. This location of the Shop Order Kit in the various pocket boards serves as a rough progress report. The Unit makes a daily floor check of the shop, recording the progress of each job. This information is transferred to the Dispatcher's File Card. Thus, the Unit maintains a current record of the progress of each job.

The functions of Dispatching as practiced at the plant accomplishes the service requirements of the shop. Although this system, as do most involving work dispatching, requires much attention to detail and great care in recording procedure, it assures ease and accuracy in ascertaining the progress of jobs. Other than the suggestion above for the possible elimination of lost time and traffic jams in the Dispatching Crib area, the author rates the NCFI system of work dispatching as adequate and well suited to the needs of the plant.

Determination of the Labor Requirements. The function of determining the labor requirements of the plant is accomplished by the Project

Scheduling Unit. The Unit recommends both inter-divisional employee transfers and adjustments in the labor force, i.e. the hiring and firing of employees. These recommendations are prepared in the form of a letter, the Monthly Man Load Summary, which is submitted through the Head of the Production Control Division to higher authority for action.

The information from the above letter is taken from the Forecast of Productive Labor chart. By comparing the available man-hours of labor with the requirements as indicated by the chart, the Unit is able to make an accurate estimate of the labor needs of the plant. Since the employees in the Machining and Assembly Divisions are skilled craftsmen, and in many cases, are capable of working in the several Units of the Machining and Assembly Divisions, the Project Scheduling Unit recommends the transfer of personnel between these two divisions to equalize the estimated work load. When the work load can not be carried by the current staff, the Unit recommends the additions to the staff.

The current trend to include the handling of labor requirements among the functions of the production control division is reflected in the procedure at MTI. Until recently, this has been the responsibility of the personnel division in most plants, or of the foreman, whose ability to foresee future changed conditions is necessarily limited. The personnel division is aided by the production control division in its job of ascertaining the type of labor to be hired to handle increased production. This system seems to meet adequately the needs of the plant.

A possible improvement in the existing system might be the

inclusion of a Man Load Chart of labor classifications to facilitate the assigning of the right man to the right job. The basis for this selection is now man-hours; a man is selected for a job without reference to his labor grade. If the degree of his skill were taken into consideration, it might insure a more exact matching of the man and the job.

With the exception of this possible refinement, the author feels that the labor requirements of MCFI are handled well with a maximum of efficiency.

Maintenance of Production Records. The function of the maintenance of production records is accomplished by the Project Scheduling Unit and the Shop Scheduling Unit. The Weekly Machine Load Report, issued by the Shop Scheduling Unit, contains the number of man-hours of work completed by the shop. This report is received by the Project Scheduling Unit and used to construct the Unit's Load and Performance chart. This chart consists of two portions, the performance portion only being discussed here. The performance chart presents four curves: the performance potential in man-hours per week; the monthly average of the performance potential; the work completed in man-hours per week; the monthly average of the work completed. The performance potential curves are based upon the estimation of the Cost Estimating Unit. The work completed curves are recorded times required by the shop to complete the Shop Order Kits. The two weekly curves show a certain amount of fluctuation. The monthly averages are used to display the trend, and serve as an efficiency standard for the shop. When the monthly average of the work completed curve drops below the eighty-five percent value of the monthly average of the performance

potential curve, the situation is investigated by the Heads of the Production Control Division and the Machining Division.

MPPI's system of maintaining production records makes shop performance readily apparent. Its weekly check is of sufficient frequency and thoroughness to assure an accurate account of work progress. Were reports made in more detail or required more often, a superfluity of records would exist, and an unnecessary strain placed on personnel effort in handling them. The system of maintaining production records as employed no doubt aids considerably the smooth and efficient operation of the plant.

Expediting of Manufactured and Purchased Items. The function of expediting manufactured and purchased items is accomplished by the Expediting Unit. To prevent a Shop Order Kit from reaching the shop prior to the time the required materials are available, the Expediting Unit ascertains that the materials are physically located in the plant before releasing the Shop Order Kit to the shop. Thus, the Unit receives the Shop Order Kit from the Methods Records Unit, and the Stub Requisition Receipt from the Supply Department. This latter form denotes the arrival of the required material at the plant. The Unit makes a weekly check of all kits being held up because of a lack of materials, and makes a bi-monthly report of such held-up kits to the Head of the Production Control Division.

An important feature of the expediting function at the plant is the manner in which the Unit handles the substitute materials. There are two general types of substitution of materials; one is a change in the type and chemical composition of the original material, and the other is a substitution of the same material allotted to dif-

ferent projects. The former substitution of material requires the approval of the Methods Section or the Engineering Department. The Expediting Unit follows through on this type of change by securing the approval for the substitution from the proper group. To accomplish the second type of substitution of material, that of using the same material which has been allotted to a different project, the Expediting Unit maintains a record of all Shop Order Kits and the required materials for each. If two Shop Order Kits use the same materials, and the available material has been allotted to one Shop Order Kit whose use is being delayed pending the arrival of other component parts, the Expediting Unit authorizes the necessary change in the allotment of the material to permit the manufacture of at least one part.

Since the ability to adapt to continuous changes is among the primary requisites of a plant such as NOPI, the flexibility of the plant's existing expediting system lends itself well to the plant's needs. A more rigid system would hamper the smooth and efficient flow of the manufactured and purchased items into the mainstream of work. In addition, the "red tape", which NOPI's flexibility of system has successfully reduced to a minimum, would cause a tie-up in the work flow; possibly necessitate an increased number of employees to handle "snarling"; and, consequently, add to the plant's personnel expenses. Increased expenditure is one of the things most diligently avoided at NOPI; efficient and speedy delivery of the product is one of the plant's chief goals. Since the expediting system at the plant prevents the former and effects the latter, it is the appraisal of this author that NOPI's present system is excellent.

Analysis of Idle Machine Time. The function of analyzing idle machine time is not accomplished at the plant. When the plant was converted to Navy operation in 1945, the basic plans were to design flexibility into the productive capacity of the plant. For this purpose, three machines per employee were installed in the shops. Due to the ever increasing demands upon the plant, the present ratio has dropped to two machines per employee. The plant, however, continues to possess an excess of machine tools in relation to the employees. Thus, an analysis of idle machine time would prove of no use to the plant.

CONCLUSIONS

This investigation has resulted in the conclusion that the production control procedure practiced at the Naval Ordnance Plant, Indianapolis, Indiana, embodies and employs all of the current basic production control principles required to meet the particular needs of such a plant. The procedure is flexible enough to assimilate and directed by individuals capable of seeing the need for the incorporation of current trends where applicable; that is, such as the assumption of the responsibility by the Production Control Division for the determination of the labor requirements. The ability of the plant to adapt its manufacturing processes to so many dissimilar items of production is the outstanding manifestation of the efficiency of the present production control procedure.

The investigation of the production control procedure at NOPI has the possible desirability for the following minor recommended changes:

1. To prevent loss of time, unnecessary material handling, and heavy traffic in the vicinity of the Dispatching Crib area, it is recommended that the material handlers be instructed to transport the work pieces and Shop Order Kits directly to the next scheduled Machining Unit instead of having these items returned to the Dispatching Crib at the completion of each Machining Unit's work on that part.
2. It is recommended that further study be conducted concerning the desirability of a Man Load Chart of labor classifications

to facilitate the forecasting of labor requirements by the Project Scheduling Unit and would consist of a more detailed breakdown of the columns of the Weekly Machine Load Report.

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Thesis 13256
H296 Hartley
An evaluation of the production control procedure at the Naval Ordnance Plant Indianapolis.

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